POULTRY SCIENCE

September, 1937, Vol. XVI, No. 5

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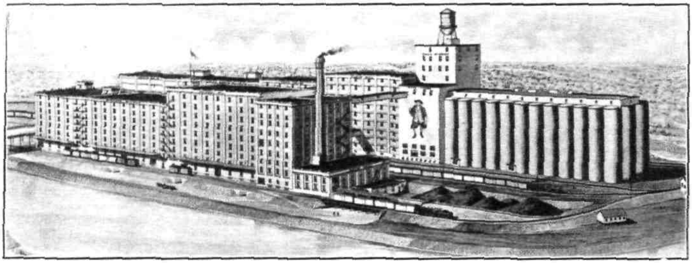
The official publication of Poultry Science Association. ¶A bi-monthly journal, published for the purpose of advancing the scientific study of poultry. ¶Manuscripts for publication should be sent to the editor. All manuscripts should be typewritten and double spaced. References to literature cited should be made by date and arranged alphabetically. Tables should not be in the body of the manuscript, but on separate sheets. Only a limited number of illustrations may be provided without the coöperation of the author. One hundred copies of reprints, without covers, will be furnished the author free. Covers and additional copies will be furnished at cost.

TERMS OF SUBSCRIPTION

Four dollars ($4.00) annually in advance; single copies seventy-five cents. The journal sent to all members of Poultry Science Association in good standing. (Annual dues include $3.50 for magazine subscription.) All subscriptions should be sent to the managing editor at 450 Ahnaip St., Menasha, Wis., or Cornell University, Ithaca, N.Y. Advertising rates on application. ¶Copyright, 1937, by Poultry Science Association.

Entered as second class matter at the postoffice at Menasha, Wisconsin, under the act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph 4, Section 412, P.L.&R., authorized April 4, 1932.



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POULTRY SCIENCE

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A Study of the Blood Picture of Poultry and Its Diagnostic Significance

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(Received for publication March 15, 1937)

THE use of the blood picture as a clinical and diagnostic criterion of pathological states in poultry has received considerable impetus in recent years. The erythrocyte count, hemoglobin index, clotting time, and (to a lesser extent) the differential count have been employed by several investigators who were interested in abnormal nutritional conditions or actual diseases. (Englebreth-Holm, 1933; Cook and Dearstyne, 1934; Dam, 1929, 1930; Harmon, 1936; Scott and Cook, 1936; Forkner, 1929.)

As a rule only part of the entire picture has been utilized, for example, hemoglobin index, clotting time, and so forth. In the course of investigations carried on in this laboratory, however, it has become apparent that in order to secure the most satisfactory results the complete picture should be determined, particularly in differential count, since certain metabolic derangements become manifest in a distorted white cell count, whereas the hemoglobin may remain essentially normal. On the other hand, an anemia may be induced without materially affecting the white cells (Cook and Scott, 1935a, 1935b; Scott and Cook, 1936).

The purpose of the present investigation was to make a thorough study of the complete blood picture of growing chicks and to observe (1) exactly where deviations from what might be considered the normal occur, and (2) what was the extent of such deviations. At the same time it was proposed to exclude such factors as bacterial or parasitic disease and extreme nutritional deficiencies. This was in order to keep the birds somewhere within the range of normal growing conditions and yet determine whether or not relatively minor disturbing factors might be reflected in distortion of the blood picture. If this is the case, then the blood picture may be demonstrated to be a more delicate and refined key to the condition of the animal than has hitherto been available.

For this purpose a large series of birds has been raised from hatching to maturity on a group of five diets, three of which were standard commercial diets and two were experimental laboratory diets.

MATERIALS AND METHODS

Ten newly hatched, White Leghorn chicks were placed on each of the five diets and were raised in battery brooders to the age of approximately four months. Adequate food and water were available at all times. As soon as the chicks attained a sufficient age (about four weeks) blood examinations were begun. All the birds in each group were examined thereafter once a week. Blood pictures were secured by drawing a small volume of blood and diluting one part to 200 with Toison's fluid. This preparation was placed in a counting chamber and the total erythrocyte and leucocyte numbers counted directly. In all cases two separate determinations were made with each preparation. For the differential count blood smears were treated with Wright's stain and several hundred cells subjected to examination. For the estimation of hemoglobin Hellige's modification of the Sahli hemometer was used. Clotting time was observed directly by placing a fresh sample of blood in a clean dry glass chamber.

DIETS

The five diets varied primarily in the type of protein which was present. All essential factors were present in adequate amount (except in diet C, which seemed to be quite deficient in vitamin G and somewhat deficient in A and D).

Diet A. A standard commercial diet. Composition according to the manufacturer's tag: ground yellow corn, ground wheat, standard wheat mill run, *fish meal*, dried whey, ground oat groats, dehydrated alfalfa meal, linseed meal, bone meal, 2½ percent mineral matter (oyster shell flour, limestone chick grit, 0.5 percent salt), sardine oil. Crude protein, not less than 17.0 percent, crude fat, not less than 3.5 percent, crude fiber, not more than 5.0 percent, crude ash, not more than 8.0 percent.*

Diet B. A standard commercial diet. Composition according to the manufacturer's tag: yellow corn meal, ground oat groats, standard wheat middlings, wheat bran, *dried buttermilk, dried skimmilk, meat and bone scrap,* alfalfa meal, minerals 2.25 percent, cod liver oil extract. Protein 16.5 percent, fat 4.5 percent, fiber 5.5 percent, ash 7 percent.

Diet C. A standard commercial diet. Composition according to the manufacturer's tag: middlings, mill run, ground wheat, ground corn, ground oats, *meat meal,* bone meal, linseed oil meal, *dried buttermilk,* cod liver oil, protein 15 percent, fat 3 percent, fiber 6 percent, ash 9 percent.

After feeding this diet for 40 days the condition of the birds was very poor and the growth was abnormally low. Since the diet was deficient in vitamins and in order to keep the birds alive and in reasonably good condition, at the end of 40 days the diet was altered by adding to each 10 kilograms of mixed feed 500 grams of alfalfa meal and 100 grams of cod liver oil (Patch).

Diet D. A standard laboratory ration which was known from previous work to produce good results. Composition in percent: corn, 40.5; wheat, 20; bran, 20; *casein,* 10; alfalfa, 5; yeast, 1; cod liver oil (Patch), 1; calcium carbonate, 1; calcium phosphate, 1; sodium chloride, 0.5. Total protein was approximately 16 percent.

Diet E. An experimental laboratory ration. Composition in percent: corn, 39; wheat, 20; bran, 20; *tuna fish meal,* 12; alfalfa, 5; yeast, 1; cod liver oil (Patch), 1; calcium carbonate, 1; calcium phosphate, 0.4; sodium chloride, 0.5. Total protein was approximately 16 percent.

RESULTS

In Tables 1-5 are presented the final data for the five diets. Each figure represents the average of 20 determinations (2 determinations for each of 10 birds). It will be seen

* In these diets, for purposes of comparison, the sources of animal protein are italicized.

TABLE 1.—*Blood pictures with diet A*

(In this and all of the following tables every item represents the mean value of two determinations made upon each of ten birds.)

Age in days	Erythrocytes No. per cmm.	Hemoglobin in percent	Clotting Time in minutes	Leucocytes No. per cmm.	Lymphocytes		Polynuclears		Basophiles		Monocytes	
					Percent	No. per cmm.	Percent	No. per cmm.	Percent	No. per cmm.	Percent	No. per cmm.
26	2,772,000	62.2	2.1	32,400	78.4	25,500	11.1	3,600	3.2	1,000	7.3	2,350
33	2,346,000	55.8	2.3	28,600	74	21,200	16.8	4,800	3.2	900	6	1,700
40	2,566,000	60.2	3.4	35,200	74	26,100	14.2	5,000	3.1	1,150	6.7	1,950
47	2,342,000	58	2.4	38,800	80.1	31,200	12.1	4,800	3.5	1,000	4.3	1,800
54	2,503,000	59.7	4.4	37,300	77.8	29,000	15.5	5,800	2.2	800	4.5	1,700
61	2,491,000	58.7	3.6	42,000	76.7	32,200	14.8	6,200	2.4	1,000	6.2	2,600
68	2,659,000	62.2	5.1	40,600	72.7	29,200	18.3	7,000	2.4	1,700	6.6	2,700
75	2,587,500	61.9	4.9	44,200	72.2	32,000	17.2	7,600	3.2	1,300	7.4	3,300
82	2,794,000	65.5	5.7	44,700	74	33,100	15	6,800	3.3	1,350	7.7	3,450
89		65	6.6	50,600	71.6	36,400	17.6	8,900	3.2	1,600	7.3	3,700
96		65.6	4.1	55,000	73.4	40,400	16.7	9,150	2.9	1,600	7	3,850
103		61.3	6.5	57,900	73.9	42,800	16	9,300	2.3	1,300	7.8	4,500
110		68.6	5.8	64,000	69.7	44,600	21.6	13,800	2	1,300	6.7	4,300
117		71	6.2	65,400	73.1	47,800	17.3	11,300	3.5	2,300	6.1	4,000
124		70	6	64,829	71.6	46,400	18.2	11,800	2.6	1,700	6.8	4,400
131		68.2	8.4	64,600	73.9	47,700	15.2	9,700	3.3	2,100	7.1	4,600
138		67.1	9.4	59,600	76.7	45,700	13.8	8,200	4	2,400	5.3	3,100
Ave.	2,562,220	63.5	5.1	48,572	74.3	35,958	15.9	7,280	2.9	1,441	6.5	3,176

that the *net averages* for from 15 to 17 different ages (that is, 300-340 separate determinations) yield values which coincide in a satisfactory manner with similar values obtained by other investigators (Cook and Dearstyne, 1934; Englebreth-Holm, 1933; Harmon, 1936; Forkner, 1929) in that the erythrocyte count approximates 2,500,000, the hemoglobin value 60 and the total white count 30,000. In fact, these values for the White Leghorn chick may now be considered as definitely established.

There are, however, certain points which merit particular mention.

1) Throughout the life of these birds, and particularly in the earlier stages there was a tendency toward increasing hemoglobin value. The trend may be indicated most simply by averaging (1) the hemoglobin values for determinations up to approximately 85 days of age and (2) the values for the remainder of the period. Calling (1) the initial average value and (2) the final average value we have the following results. (In all cases where the hemoglobin is expressed in percentage the weight equivalent of 100 percent is 17 grams hemoglobin per 100 cubic centimeters blood.)

Diet A: initial value, 60.5; final value, 66.4.
Diet B: initial value, 60.5; final value, 66.5.
Diet C: initial value, 56.1; final value, 59.7.
Diet D: initial value, 64.5; final value, 71.6.
Diet E: initial value, 60.4; final value, 65.6.

2) The erythrocyte count, within experimental error, showed the same variations as did the hemoglobin number. Therefore at the end of 12 weeks, erythrocyte counts were discontinued.

3) Disregarding the general uniform trend toward increasing hemoglobin, the net general average for the value of the latter in each group showed significant variations. Thus (from the tables) Diets A, B, and E gave 63.5, 63.5 and 63.1 respectively. In other words, in these three cases the hemoglobin level throughout was almost identical. But Diet C gave 57.8, and Diet D gave 68.1, very definitely low and high respectively.

TABLE 2.—*Blood pictures with diet B*

Age in days	Erythrocytes No. per cmm.	Hemoglobin in percent	Clotting Time in minutes	Leucocytes No. per cmm.	Lymphocytes		Polynuclears		Basophiles		Monocytes	
					Per-cent	No. per cmm.	Per-cent	No. per cmm.	Per-cent	No. per cmm.	Per-cent	No. per cmm.
27	2,378,000	56.2	2.4	27,600	72	19,900	19.4	5,350	2	550	6.6	1,850
34	2,624,000	58	3	24,600	74.2	18,500	17.8	4,300	2.4	500	5.6	1,300
41	2,324,000	53.4	2.2	31,600	79.4	25,050	13.6	4,300	2.8	900	4.2	1,350
48	2,572,000	65.7	2	25,300	76.7	19,500	16.8	4,250	1.8	400	4.6	1,150
55	2,545,000	58.2	4.2	27,700	77	21,400	14.8	4,100	2.6	700	5.4	1,500
62	2,817,000	60.6	3.4	25,700	77.4	19,700	13.9	3,600	3.4	900	5.8	1,500
71	2,675,000	61.9	3.3	25,300	75	18,900	14.5	3,700	3.6	950	6.9	1,750
77	2,580,000	61.6	4	28,200	75.8	20,200	13.4	3,900	3.1	900	7.7	2,200
84	2,792,000	68.8	3.5	30,400	74.9	22,800	15.1	4,550	2.8	850	7.2	2,200
90		65.6	3.8	35,300	75.5	26,650	15.5	5,150	2.7	950	7.3	2,550
97		67.3	4.9	31,600	70.5	22,280	19.3	6,100	2.7	850	7.5	2,370
104		64.9	7.2	30,500	67.9	20,700	21.7	6,600	2.4	750	8	2,450
111		70.3	6.1	30,600	74.1	22,650	17.7	5,400	2.4	750	5.8	1,800
118		64.6	9.6	34,500	73.1	25,200	17.4	6,000	3	1,100	6.4	2,200
125		68	6	36,000	72	26,000	17.9	6,500	2.7	900	7.2	2,600
132		72.1	10.9	36,600	72.1	26,400	18.4	6,720	2.7	980	6.6	2,400
Ave.	2,592,300	63.5	4.7	22,240	74.2	22,240	16.7	5,032	2.7	808	6.4	1,948

The slight anemia with Diet C may be attributed probably to the vitamin deficiency which existed up to the fortieth day. The growth of the birds on this diet as well as their general condition was poor up to this point. The incorporation of alfalfa and cod liver oil in the diet removed the deficiency and thereafter the birds showed improvement in all respects and ultimately became quite normal.

Diet D, which included casein as a protein supplement showed a quite high hemoglobin percentage. This is in conformity with previous results obtained in this laboratory, for an unusually high hemoglobin value has always been observed whenever casein was the principal source of protein.

4) With respect to the differential counts

TABLE 3.—*Blood pictures with diet C*

Age in days	Erythrocytes No. per cmm.	Hemoglobin in percent	Clotting Time in minutes	Leucocytes No. per cmm.	Lymphocytes		Polynuclears		Basophiles		Monocytes	
					Per cent	No. per cmm.	Per cent	No. per cmm.	Per cent	No. per cmm.	Per cent	No. per cmm.
28	2,432,000	48.5	4.2	24,700	73.7	18,200	17	4,200	2.7	670	6.2	1,500
35	2,865,000	60.2	2.9	29,400	64	18,800	28	8,300	2.6	700	5.4	1,600
42	2,437,000	52.7	3.	29,200	76	22,200	15	4,400	1.7	500	7.2	2,100
49	2,070,000	53.9	2.1	19,600	76.8	15,000	17.2	3,400	1.8	400	4.4	800
56	2,430,000	55.2	2.3	27,700	72	19,900	19	5,300	3.1	860	6.1	1,640
63	2,520,000	58.7	3.	26,000	71	18,500	19.1	5,000	3.2	830	6.1	1,600
70	2,590,000	60.1	2.	25,700	70.2	18,000	23	5,900	2.1	540	5.8	1,500
77	2,510,000	57.4	3.9	30,000	72.3	21,700	17.3	5,200	2.7	830	7.5	2,300
84	2,560,000	58.3	3.1	33,100	71	23,500	18.7	6,300	2.4	790	7.1	2,350
90		62.	3.3	31,000	70.4	21,800	20	6,200	2.1	650	7.5	2,340
99		72.7	3.4	35,000	68.2	23,900	21.5	7,500	2.3	800	7	2,450
105		62.4	6.2	33,000	71	23,400	19.4	6,400	2.1	700	7.4	2,400
112		60.4	6.4	37,400	74	27,700	18	6,700	2.2	800	5.9	2,200
126		57.	14.5	44,300	77	34,100	16.6	7,400	1.4	620	4.5	2,000
132		58.1	2.8	38,600	74.8	28,900	16.8	6,500	2.2	830	6.2	2,400
Ave.	2,490,444	57.8	4.1	30,980	72.1	22,373	15.1	5,913	2.3	701	6.2	1,945

TABLE 4.—*Blood pictures with diet D*

Age in days	Erythrocytes No. per cmm.	Hemoglobin in per cent	Clotting Time in minutes	Leucocytes No. per cmm.	Lymphocytes		Polynuclears		Basophiles		Monocytes	
					Per cent	No. per cmm	Per cent	No. per cmm.	Per cent	No. per cmm.	Per cent	No. per cmm.
29	2,576,000	61.8	2.3	22,800	70.2	16,000	20.4	4,600	2.4	550	7	1,600
36	2,694,000	58	2.4	31,800	77.6	24,700	16.2	5,100	1.2	400	5	1,600
43	2,372,000	60.2	1.3	34,000	81.4	27,800	11.8	4,000	2.2	700	4.6	1,500
49	2,536,000	66.9	2.3	22,600	79.7	18,000	14.2	3,200	2.1	500	4	900
57	2,593,000	61.9	3.8	23,400	72.8	17,000	17.6	4,100	3.8	900	5.8	1,400
64	2,843,000	65.1	2.8	28,400	75.8	21,600	14.8	4,200	3.2	900	6	1,700
71	2,834,000	68.8	3.7	27,600	73.9	20,400	17.3	4,800	2.8	750	6	1,650
78	2,890,000	68.4	3.8	28,500	74.4	21,200	15.1	4,300	3.7	1,050	6.8	1,950
85	2,886,000	69.8	7.5	30,400	73.3	22,300	15.5	4,700	3.1	940	8.1	2,460
91		71.2	2.8	32,400	71.7	23,200	17.6	5,700	2.9	900	7.8	2,600
98		71.3	5.7	31,700	69.8	22,150	19.7	6,200	2.8	900	7.7	2,450
105		72.4	7.7	29,600	72.3	21,400	17.5	5,200	2.3	650	7.9	2,350
112		75.1	6.7	32,700	69	22,600	21.1	6,900	2.9	950	6.3	2,050
119		73.8	4.8	32,700	67.4	22,000	23.3	7,720	3.2	1,050	5.9	1,930
126		74.3	6.9	41,900	72	30,200	19	8,000	2.8	1,200	6	2,500
133		71.5	7.6	37,100	71.4	26,500	19.2	7,100	2.6	950	6.8	2,550
Ave.	2,691,555	68.1	4.5	30,475	73.3	22,315	15.1	5,363	2.7	830	6.3	1,949

it will be observed that whereas in some *cases the total white cells varied in number,* the differential counts were remarkably uniform. Thus the percentage of lymphocytes for the five diets A to E were respectively 74.3, 74.2, 72.1, 73.3, and 73.4. The polynuclears, basophiles and monocytes were equally constant, that is within experimental error. This finding is of significance in connection with results recently obtained in *this laboratory (Scott and Cook, 1936). It* was there shown that the lack of antihemorrhagic factor and the presence of nitrogrenous bases might give rise to different types of distorted white cell pictures which could be distinguished by marked variations in the differential count.

5) The total white counts in four of the

TABLE 5.—*Blood pictures with diet E*

Age in days	Erythrocytes No. per cmm.	Hemoglobin in per cent	Clotting Time in minutes	Leucocytes No. per cmm.	Lymphocytes		Polynuclears		Basophiles		Monocytes	
					Per cent	No. per cmm.	Per cent	No. per cmm.	Per cent	No. per cmm.	Per cent	No. per cmm.
30	2,726,000	60.8	3.8	28,100	67.6	18,900	21.4	6,000	5	1,400	6	1,700
37	2,315,000	54.2	3	22,250	72	16,000	18	4,000	1.75	400	8.25	1,850
44	*2,296,000*	*58.2*	*2.4*	*30,600*	*81*	*24,800*	*13.6*	*4,150*	*2.4*	*750*	*3*	*900*
50	2,425,000	57.2	2	27,000	76.5	20,650	15.6	4,200	1.5	700	5.4	1,450
58	2,451,000	59.3	4.7	26,000	74.1	19,300	15.75	4,100	3.75	1,000	6.4	1,600
65	2,648,000	62.1	2.7	25,600	74.5	19,000	16.4	4,200	2.6	700	6.5	1,700
72	2,690,000	62.6	3.1	28,370	78	22,200	13.7	3,900	1.8	550	6.5	1,720
79	2,871,000	64	3.8	31,875	73	23,200	16.5	5,300	3	1,000	7.5	2,375
86	2,743,000	65	6.3	28,125	71	20,000	19.5	5,500	2.7	800	1.8	1,825
91		66.3	3	29,375	72	21,100	17.7	5,400	2	500	8.3	2,375
101		68	7.2	27,300	72.1	19,700	17.3	4,750	2.5	700	8.1	2,200
107		66.1	7	30,625	71.8	22,000	20	6,000	1.6	400	7.6	2,225
114		68	6.8	29,400	73.7	21,700	16.6	4,900	2.8	800	6.8	2,000
128		70.1	5	51,366	71.6	36,800	19.5	10,000	2.5	1,300	6.2	3,200
133		65.2	7.7	35,875	72.2	25,900	18.3	6,575	2.2	800	6.8	2,450
Ave.	2,573,888	63.1	4.6	30,088	73.4	22,083	17.3	5,231	2.2	786	6.3	1,971

diets here studied were almost identical. Thus the counts for B; C, D and E were respectively 30,093, 30,980, 30,475, and 30,088. These values very closely approach those found by Scott and Cook (1936) and Englebreth-Holm (1933). Hence the normal white count of the White Leghorn may be considered established at approximately 30,000.

The fact that the four diets mentioned produced perfectly normal leucocyte values is an indication that no serious deficiency or toxicity is involved—at least of such a nature as to be reflected in the very sensitive white cell system of the bird. It is true that during the early period of feeding diet C the leucocytes were at a low level (26,000 average from 28 to 70 days) but subsequent to rectification of the diet the count rose to quite normal values.

The fifth diet (diet A) produced a very great increase in the white cell count (that is, net average 48,570). That this was a permanent condition, and not one induced by some temporary or adventitious infection is shown by the actual week to week determinations. Thus the data on two individual birds were as follows:

Bird No. 1, total white counts *in thousands* from 7th to 19th week inclusive, 37, 37, 41, 47, 46, 40, 52, 74, 64, 65 ,71, 86, 74.

Bird No. 5, total white counts *in thousands* from 7th to 19th week inclusive: 59, 54, 47, 53, 64, 57, 65, 72, 71, 86, 94, 60, 83.

This condition of consistently high leucocyte counts is characteristic of diets involving a lack of anti-hemorrhagic factor or presence of sub-acute quantities of nitrogenous bases (Scott and Cook 1936).

6) The clotting time, which, under certain conditions, may be very greatly altered (for example, lack of anti-hemorrhagic factor) was practically identical in all cases.

DISCUSSION

In conclusion it may be pointed out that since the red, white, and differential counts of normal poultry blood are now well established, these counts may be used separately and in conjunction as diagnostic criteria for many kinds of dietary and pathological disorders. Examples of such use have been cited here in connection with the feeding of ordinary diets. It is probable that under other field or laboratory conditions new and characteristic types of blood picture might be obtained.

SUMMARY

An extensive study was made of the blood picture of White Leghorn chicks, including red cell count, total white count, differential count, clotting time, and hemoglobin value.

By feeding five diets (three of which were standard commercial diets and two laboratory diets), certain abnormalities in the normal picture were produced which have a general diagnostic value.

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A Test of the Accuracy of Trap-Nest Records

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(Received for publication, March 15, 1937)

IN A recent paper Amiet (1936) suggested that the methods of statistics might be used to good advantage in record of performance inspection work. As a contribution to this field, Hendricks (1937) showed that the familiar chi-square distribution may be employed to test the accuracy of trap-nest records. Although the development of the test invloved some mathematical theory with which flock inspectors and supervisors are usually not familiar, the practical application of the test is quite simple. The present paper offers a detailed explanation of the practical application of the test to those workers who may have some occasion to employ it.

The test is designed to determine whether or not the numbers of eggs produced by a given flock of birds on inspection days, when the trap-nesting is done by the inspector, differ significantly from the numbers of eggs which would be expected on the basis of the production reported by the flock owner for other days. This is accomplished by calculating a statistic, chi-square, which may be denoted by the symbol, x^2. If the records are accurate, the value of x^2 should lie between zero and some maximum value which depends upon the number of inspection periods involved.

In order to compute the numerical value of x^2 for a given set of records, the following data are needed:

(1) The number of monthly inspections made during the year, which may be denoted by the symbol, s.

(2) The number of eggs produced by the flock during each of the s inspection periods. Let x_1 be the number produced during the first period, x_2 the number produced during the second, and so forth.

(3) The length of each inspection period in days. Let k_1 be the length of the first period, k_2 the length of the second, and so forth.

(4) The number of birds in the flock during each inspection period. Let n_1 be the number during the first period, n_2 the number during the second, and so forth.

(5) The egg production per bird per day in each month, computed on a hen-day basis from the flock owner's records over a fairly long period in each month. The period should preferably include at least several days before and after inspection. Let p_1 represent the production per bird per day in the first month, p_2 the production per bird per day in the second month, and so forth.

Tbe application of the test involves the computation of the value of x^2 and an examination of a table of values of x^2, such as that given by Fisher (1934), to determine whether or not that value is excessively large. The number of monthly inspection periods, s, corresponds to the number of degrees of freedom which specifies the part of Fisher's table which should be examined. If the magnitude of the observed

value of x^2 is such that it is likely to be equalled or exceeded by chance only once in a hundred trials, or still less frequently, the given set of records should be regarded with suspicion.

The details of the method can be explained most easily by considering a particular example. Such an example is given in Table 1. The data used in the construction of this table are, in part, the data reported for an R. O. P. flock by Amiet (1936). All additional data which were required for the calculations were supplied to the author through the kindness of Mr. Amiet.

The first column in Table 1 gives the months in which the flock was inspected. The data in the second column under the heading, x_i, are the numbers of eggs produced by the flock during the 5 inspection periods. The subscript, i, in the symbol, x_i, is understood to assume the values 1, 2, 3, 4, and 5, each value corresponding to one of the inspection periods. The data in the third column under the heading, k_i, give the length of each inspection period in days. For this particular set of records, each inspection period consisted of only one day. The data in the fourth column under the heading, n_i, are the numbers of birds in the flock during the various periods. The data in the fifth column under the heading, p_i, give the egg production per bird per day, computed from the flock owner's record of egg production for a 20-day period consisting of 10 days before and after inspection, for each of the 5 months. The data in the sixth column under the heading, $k_i n_i p_i$, represent the number of eggs which would be expected for each inspection period on the basis of the production reported by the flock owner during the 10 days before, and the 10 days after, inspection. Each value in this column may be computed by multiplying the production per bird per day, as given in the fifth column, by the number of birds and the number of days in the inspection period. The data in the seventh column under the heading, $k_i n_i p_i (1-p_i)$, may be computed by multiplying the expected egg production, $k_i n_i p_i$, by the quantity, $(1-p_i)$. Each value in this column represents the squared standard error of the corresponding observed egg production, x_i. The data in the eighth column under the heading, $\frac{(x_i-k_i n_i p_i)^2}{k_i n_i p_i(1-p_i)}$ may be computed by squaring the deviation of the observed production

TABLE 1.—*Application of the chi-square test to trap-nest records for an R. O. P. flock*

Month	No. of eggs produced[a] x_i	Length of inspection period (days) k_i	No. of birds in flock[a] n_i	Production per bird per day[b] p_i	No. of eggs expected[a] $k_i n_i p_i$	$k_i n_i p_i(1-p_i)$	$\frac{(x_i-k_i n_i p_i)^2}{k_i n_i p_i(1-p_i)}$
Jan.	77	1	196	0.4520	88.6	48.55	2.77
Mar.	106	1	171	0.6392	109.3	39.44	0.28
Apr.	92	1	141	0.6688	94.3	31.23	0.17
May	73	1	120	0.6325	75.9	27.89	0.30
July	65	1	101	0.6050	61.1	24.13	0.63
x^2							4.15

$x^2=4.15$
Degrees of freedom = 5
P = 0.5

[a] During inspection period.
[b] Based on flock owner's records.

from the expected production for each inspection period and dividing the result by the squared standard error of the observed production as given in the seventh column.

The value of x^2 is obtained by adding the figures in the eighth column of the table. For this set of records x^2 has the value, 4.15. Since there were five inspection periods, Fisher's table may be consulted to determine whether or not this value is excessively large for five degrees of freedom. This reveals that a value as large as 4.15, or larger, may be expected to arise by chance about 5 times in 10 trials. Therefore, the value, 4.15, is well within the allowable range of variation and there is no reason to question the accuracy of the given set of records on the basis of the chi-square test.

As an illustration of the usefulness of the chi-square test in inspection work, consider the data in Table 2. This table presents the results of applying the test to 5 sets of trap-nest records discussed by Amiet (1936). The additional data which were needed for the computations were supplied to the author by him.

The values of x^2 obtained are given in the third column of the table. The data in the fourth column under the heading, degrees of freedom, gives the number of inspections to which each flock was subjected during the year. The data in the last column under the heading, P, give the relative frequency with which each of the observed values of x^2 is likely to be equalled or exceeded by chance if the records are accurate.

The conclusions which may be drawn from this table are in agreement with those reported by Amiet (1936), namely, that the records of flock A for both years should be regarded with suspicion while the records of the other flocks show nothing more than allowable variation.

Although the agreement of the results obtained by means of the chi-square test with the conclusions reported by Amiet (1936) serves well to strengthen one's confidence in the validity of the test, it immediately raises the question of whether or not such a test is needed when similar conclusions can be reached less laboriously by another method. In this connection, the author would like to call attention to the fact that the test can serve more purposes than the mere detection of inaccurate records. In the first place, the test is based upon established mathematical theory and, therefore, offers the inspector something tangible to exhibit in support of his conclusions regarding a given set of records. In the second place, a knowledge on the part of flock owners that a scientific test of the accuracy of trap-nest records is available may help to discourage the minority which occasionally is tempted to tamper with such records. These considerations are sufficient to justify the extra amount of work involved in the use of the chi-square test. However, there does not seem to be any need for applying the test

TABLE 2.—*Results of applying the chi-square test to 5 sets of trap-nest records.*

Flock	Year	x^2	Degrees of freedom	P*
A	1933 34	105.48	9	Less than 0.01
A	1935	310.16	6	Less than 0.01
B	1935	4.15	5	0.5
C	1935	1.70	5	0.9
D	1933 34	10.33	8	0.2

* Records yielding a value of P equal to, or less than, 0.01 should be regarded with suspicion.

to all records with which the inspector comes into contact. From the point of view of economy, it seems desirable to restrict its use to records which the inspector has reason to question after applying the less laborious tests which are already in use.

In the practical application of the test, the inspector may not be interested in knowing the exact relative frequency with which an observed value of x^2 is likely to arise by chance. It will usually be sufficient to determine whether or not that value is less than some maximum permissible value. As an arbitrary standard, we may assume that the largest value of x^2 likely to arise by chance in the case of normal records is a value such that it may be expected to be equalled or exceeded by chance only once in a hundred trials.

TABLE 3.—*Largest values of x^2 likely to be obtained from normal trap-nest records*

Number of inspection periods	Value of x^2
1	6.635
2	9.210
3	11.341
4	13.277
5	15.086
6	16.812
7	18.475
8	20.090
9	21.666
10	23.209
11	24.725
12	26.217

Table 3 presents such maximum values of x^2 for records involving various numbers of inspection periods. If an observed value of x^2 is as large as, or larger than, the value given in Table 3 for the appropriate number of inspection periods, the records should be regarded with suspicion. Table 3 is reproduced from the author's earlier paper. The data contained therein were taken from the table of values of x^2 given by Fisher (1934).

In conclusion, the author would like to point out that the test must be used intelligently if satisfactory results are to be obtained. Certain precautions which should be observed may be mentioned at this time.

For example, an unusually large value of x^2 may occasionally arise by chance even though the probability of such an occurrence is very small. Therefore, a large value of x^2, obtained from a given set of records, does not serve as absolute proof that the records have been subjected to tampering. It merely indicates that the records should be regarded with suspicion.

Another point which may be discussed concerns the computation of the value of x^2 for a set of records. The values of the p_i, which enter into the computation, should each be based on a period of time which is fairly long in relation to the length of the inspection period. If this precaution is not observed, sampling errors in the values of the p_i will cause trouble. However, the period should not be so long that it includes days in which egg production is obviously much different from the production in the neighborhood of the inspection period because of some condition for which the inspector has received a satisfactory explanation. The period of time used in computing each value of p_i should be such that the ability of the birds to produce eggs during this period may be regarded as equal to their ability to produce during the corresponding inspection period.

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Extension Looks to Research

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(Presented at annual meeting, August 1936; received for publication March 19, 1937)

THE land grant colleges were established by law as the agencies within the states responsible among other things for finding, analyzing, and disseminating information on the technical phases of scientific agricultural production. The most effective fulfillment of this job depends on proper coördination and coöperation in the administration of the research, teaching, and extension programs, and a feeling on the part of the workers that the entire state is the campus of the experiment station and the agricultural college.

It is my object as an extension worker to point out in this paper some of the ways in which the program of the extension service, which is the agency responsible for the dissemination of agricultural information within the states, may be made more effective through better coöperation and coordination with the research program. Not so many years ago, the material published by the agricultural experiment stations was going to relatively few farmers, and those farmers who did receive it frequently could not understand the material because it was too technical. It was, and still is, one of the duties of the extension worker to take the experimental facts established by the research worker and interpret these facts into everyday, usable ideas and practices that will help the poultryman to develop more efficient methods of production and to more effectively control the many problems incident to efficient production.

In a sense, the extension worker is a press-agent and sales promotion man for the experiment station and here, as in a business institution, there needs to be the closest coöperation between the production department and the sales department.

The extension man in his work with the poultrymen is in constant contact with the practical problems of the industry, particularly those problems which affect the economical production of poultry and eggs, and have a bearing on the labor income of the poultryman. The research worker on the other hand is frequently a highly trained scientist concerned only with certain phases of the problems experienced by the poultrymen and in making studies in his particular field. The research program is frequently so confining that the research worker loses contact with the economic problems of the industry and finds it difficult to keep his hand on the pulse of the industry. Even if he were able to, it might tend to divert his attention from the specific problems on which he was working, and cause him to diversify his program to the point where it might lose much of its value to the industry.

Many research workers are handicapped by this very situation for, in many cases, they are forced to give a part of their time to teaching and extension activities as well as to research work; while in other cases, they are forced to devote a part of their time to dairy and swine problems as well as to poultry problems in their particular field.

In order, therefore, that the research workers may organize their program for the most efficient use of their time, it would seem logical for them to depend upon the field worker or extension specialist to a large extent for information on the needs of the industry. This means that the exten-

sion specialist must be an analyst of problems just as the research man is an analyst of data. The extension specialist must be able to diagnose the immediate needs of the poultryman and at the same time appreciate the problems which are likely to appear in the long time development of the industry. It would then become one of the tasks of the extension worker to help determine the problems, and the task of the research worker to attempt to solve the problems, but unless both are capable of recognizing the true facts and have the ability to analyze the situation and arrive at the right conclusions, the industry will suffer and the institutions which they represent will lose caste in the eyes of the poultrymen.

Hence, an organization to be effective in studying and disseminating the information on the problems of the poultryman must be one in which the extension man through his contacts with the problems of practical poultry production is called upon to help point out the problems in the industry which are of most economic significance, and the facts which bear on the problems, and to suggest the order in which the problems should be attacked.

The research worker must study the problem, recognize the phases on which information is lacking, develop his research program to determine a solution of the unknown factors, and then, through careful study and analysis of his data, arrive at a practical solution.

If this need for coöperation between the research and extension workers on the determination of the problems to be studied has been over-emphasized, it is doubtless because as an extension specialist I have frequently found myself in the position of being unable to help solve the problems of producers due to a lack of scientific facts bearing on the situation.

The extension specialist can teach the poultrymen much about the fundamentals of breeding, feeding, housing, management, and so forth, but it means little to the poultryman to know these things when he experiences an outbreak of paralysis or some other problem which causes so serious a mortality in his flock that he cannot make any profit even though he follows the best methods of feeding, breeding, and housing. Any program of research which is not based on the fundamental economic needs of the poultrymen, even though it may ferret out interesting information, will be of little value to him if he is forced out of the business due to some problem on which we lack information.

It is true that those charged with the responsibility of developing a research program are faced with the necessity of showing the public that something is being accomplished which is worth while and justifies the expenditure involved, and at the same time must be working on fundamental problems which may involve a long time and considerable expense and yet may never result in a solution to the problem. There is as a result the need of carrying on simple tests on many of the unanswered questions of the poultryman which do not require involved scientific procedure to meet the immediate need of keeping constantly before the public the fact that work is being conducted which is of value to the industry.

Many of these experiments may be of great interest and of little economic significance to the industry, but they are expedient and necessary under our present system.

However, unless this type of research program is supplemented with another which is more extensive and directed toward the solution of the real economic problems of the poultryman, the research program is not meeting the challenge of the industry.

The poultry research programs in the

various states can also be better coördinated in respect to the phases of poultry problems studied. Since the problems of the poultrymen are not limited by state boundary lines, it is not necessary for every experiment station to study every poultry problem.

Inasmuch as the United States Department of Agriculture now supplies over one-third of all the money expended in agricultural research in the various state experiment stations in this country, it would seem advisable that the states be divided into groups and each group concentrate their research activities in a certain field of poultry problems. Coöperation between the states in the selection of the field of poultry problems to which their research activity would be directed would eliminate much unnecessary duplication of research work and through better coördination and coöperation between departments working in the same field, each would more effectively meet the needs of the industry Every research institution should strive toward accurate scientific research in a few fields rather than inaccurate and careless work in all fields.

Such coördination of the agricultural research activities of the experiment stations would lead to concentration of activities in certain fields and consequently make it possible to have better technically trained research workers. In the field of medicine, the general practitioneer does not usually make a good research worker; likewise most research workers in poultry with a background of training in some basic science should do more effective work. With our present situation in some institutions, one individual with a general training in veterinary science is expected not only to teach courses in poultry diseases, but also to do diagnostic work and develop a research program in the same field.

Compare, if you will, this situation with the possibilities that might come through concentration of the research activities in the field of poultry disease control at certain institutions, which would thus make it possible to have a staff comprised of men trained in the fields of physiology, anatomy, histology, bacteriology, parasitology, and pathology, working together in a well organized disease research program. The average veterinarian is trained for practice in the field of veterinary medicine and not for research in the field of poultry diseases.

The relationship of research and extension activities has also suffered from the tendency of some research workers to publish the results of experiments without sufficient data to justify their conclusions. The extension man is expected to bring the latest research findings to the attention of the poultryman, and it is not because of the change that it involves that the extension worker objects, because after all the extension man lives on changes. The extension worker needs fresh, live, and growing subject matter by which to bring stimulating viewpoints to bear on old and new problems, but the extension worker does object to making recommendations based on conclusions drawn from inadequate data or insufficient number of trials. It is the extension worker that must live down the mistakes of the research worker when recommendations are based on inadequate scientific data and it is embarrassing to the extension worker to find that a recommendation he has been making for many years such as the delay of feeding chicks until they are 72 hours of age is wrong; but when the research worker presents conclusive data, the average extension man does not hesitate to say that he was wrong, and change his recommendation in line with the new data.

Poultrymen frequently find it difficult to understand why research workers studying the same problems at different institutions

secure such divergent results. This has been especially true with regard to the studies made of the cause of range paralysis. It would seem that publications dealing with a subject on which there is such a wide disagreement of experimental findings might well be limited to technical reports, and thus avoid much of the confusion on the part of poultry men.

It has not been my object to criticize or belittle the research worker, but rather to point out that the extension worker is dependent on the research worker to supply him with accurate information in order that his teachings may hold the strivings of poultrymen toward social and economic betterment. The extension program, in fact, is dependent on the research program for its very existence.

If extension teachings in poultry presume to keep pace with the dynamic problems of commercial poultry production, the research programs must be built around the unanswered economic problems of the poultry raiser and the research work must be carried on in the most effective and efficient manner.

Proper coöperation and coördination of the research, teaching, and extension activities in the field of poultry husbandry within a state and between states cannot fail to strengthen the respect and support that every institution will receive from its poultry industry.

Body Weight, Egg Weight, Sexual Maturity and Growth Rate in the Domestic Fowl*

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(Received for publication March 20, 1937)

NUMEROUS investigations have been conducted in the past few years in an attempt to increase our knowledge of the relationship between body weight, egg weight, and age at first egg in the domestic fowl. Many studies have shown that there is a relationship between these characters, but, because body weights and egg weights have not been taken at the same times, it has been difficult to arrive at conclusions concerning their interrelation. Rhynehart (1929) for example shows that large birds tend to produce fewer second-grade eggs than smaller birds. Atwood (1925) has observed that in White Leghorns the heavier birds laid the larger eggs. Several other authors have corroborated the findings of these two investigators.

The things to remember, however, are (1) the time at which the body weights and egg weights were observed, and (2) the ultimate weight of the birds. Mean yearly egg weight is not a satisfactory criterion of measurement unless the birds are all late maturing sexually or have attained previously their maximum adult egg weight. The same will hold for body weights. Correlations between body weight and egg weight are open to several interpretations and the age of the bird should be considered in making these interpretations.

The weight of the egg during the first few months of laying is dependent upon the size of the bird. A bird that has not attained its maximum adult weight will lay a smaller egg at this time than will the same bird when it reaches maximum adult body weight. Hays (1930) observed that birds which weighed the most when they commenced laying laid the largest eggs up to the first of January. Again this relationship is dependent on when the bird starts to lay. A bird that begins to lay at an early age will have a lower mean egg weight than will a bird laying at a later age, although they may both be genetically the same with reference to maximum egg weight. Further, a late sexually maturing bird will weigh more at sexual maturity than would the same bird if it were early sexually maturing. The weight at which a bird can lay its first egg is somewhat restricted; for Waters (1934) has shown that most birds will not lay until approximately 90 percent of their weight has been attained.

Jull (1924) has shown that a significant correlation exists between age in days when laying commences and the mean weight of the first 10 eggs laid in the pullet year. The earlier laying commences, the smaller the eggs. This is simply a phenomenon of growth for it is clear that the early maturing bird has not as yet attained her maximum body size and all of the organs of

* Journal Paper No. J443 of the Iowa Agricultural Experiment Station. Project 54.

the bird will increase with age until the bird has attained its maximum adult body weight. The poultry breeder is interested in some measurement of egg weight that will allow him to weigh the minimum number of eggs and still obtain an adequate measure of the inherent egg weight of a bird. This measurement should be taken after the bird has completed its growth.

Jull (1932) asks: "Since body weight has been shown to be so closely associated with egg weight, is the problem of the inheritance of egg weight largely a problem of the inheritance of body weight?" and further "is the inheritance of egg weight to be controlled for the most part by controlling age in days that laying commences in relation to body weight?" These questions stress the general problem and definitely these factors must be considered before a solution to the inheritance of egg weight can be determined.

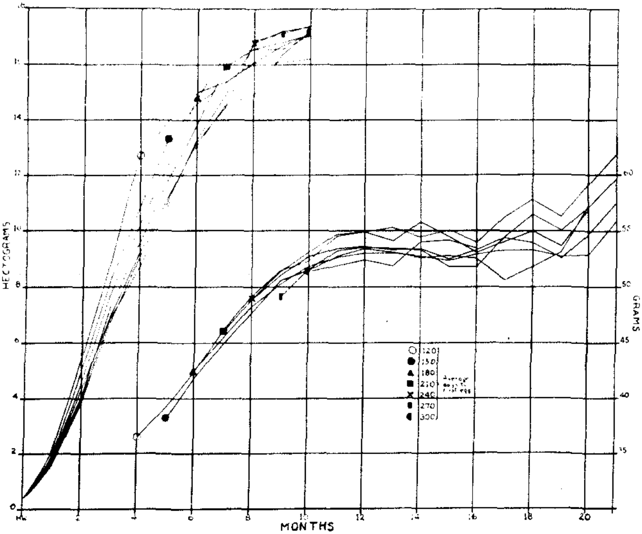

FIG. 1. Growth curves showing the relationship of body weight, egg weight, and sexual maturity, Leghorns only.

MATERIALS

The materials used in this study pertained to 2,276 Single Comb White Leghorn fowl, some of which were non-inbred and some of which had various degrees of inbreeding. The study covered four years from 1931 to 1934, inclusive. Body weights were obtained at hatching time and at monthly intervals thereafter, until maximum body weight, which occurs at approximately 10 months of age, was attained.

Not all birds used in this study were weighed but a random sample was chosen at hatching time and weights were obtained from this sample for the period indicated. The eggs from all birds during the years 1931 and 1932 were weighed daily while the eggs from all birds during 1933 and 1934 were weighed at least one week each month.

TABLE 1.—*Mean body weight and mean egg weight for all Leghorns used in this study grouped according to age at first egg, together with the frequencies for each group*

Age in months	Body Weight*													
	120 days to first egg		150 days to first egg		180 days to first egg		210 days to first egg		240 days to first egg		270 days to first egg		300 days to first egg	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
H.W.	15	38	112	38	217	38	198	39	203	39	30	39	11	39
1	15	204	112	186	220	174	194	170	150	154	30	168	11	160
2	15	541	112	498	220	456	194	403	149	386	30	428	11	392
3	15	893	112	827	220	777	193	728	149	670	30	693	11	691
4	15	1273	111	1091	219	1021	193	954	149	904	30	920	11	873
5	14	1400	111	1334	217	1243	192	1185	148	1109	30	1123	11	1091
6	14	1500	112	1460	216	1476	192	1377	148	1330	30	1320	10	1310
7	14	1536	109	1532	216	1637	189	1590	148	1568	30	1543	10	1450
8	13	1608	108	1607	211	1657	186	1658	151	1681	29	1693	11	1491
9	12	1667	103	1606	208	1656	180	1680	144	1720	27	1711	11	1636
10	12	1708	95	1619	190	1708	168	1707	134	1736	27	1737	11	1718
	Egg Weight*													
4	29	36.4												
5	25	39.1	393	38.1										
6	24	42.3	359	41.8	869	42.4								
7	21	46.0	306	44.8	767	45.4	610	46.0						
8	20	49.2	259	47.6	620	48.2	503	48.8	280	48.8				
9	16	51.4	213	50.5	551	50.3	416	51.0	207	51.3	78	49.0		
10	18	52.3	204	51.4	509	51.8	391	52.8	201	53.1	57	51.5	22	51.3
11	13	54.5	194	52.7	502	52.6	380	53.4	196	54.7	47	53.2	17	51.8
12	18	54.9	190	53.0	488	53.0	364	53.6	177	54.9	50	53.5	16	52.4
13	20	54.1	179	53.4	439	53.0	312	53.3	156	55.3	43	53.4	14	51.8
14	16	55.8	148	53.1	391	53.7	274	53.4	128	54.5	33	53.3	12	54.0
15	13	54.5	120	52.6	321	53.5	220	53.5	104	55.1	24	51.8	8	54.3
16	10	53.0	94	52.8	265	53.0	181	53.5	82	54.0	25	51.8	6	53.5
17	7	54.1	78	52.5	216	53.3	116	54.4	50	56.3	14	54.5	2	62.5
18	8	55.0	75	50.6	137	53.4	74	54.0	37	57.8	15	56.5	3	57.0
19	3	53.7	52	51.8	84	52.7	26	52.7	10	56.3	7	55.1		
20	1	57.0	33	53.1	58	53.0	22	54.7	5	58.2	5	57.2		
21	—	—	20	57.3	39	55.9	17	57.6	9	61.9	4	60.0		

* All weights in grams.

Pedigree records were obtained for every bird used in this study and all birds were trapnested.

The non-inbred Leghorns have been bred at the Iowa State Experiment Station flock without the introduction of new material for approximately 20 years. The inbred Leghorn stock is described in Research Bulletin 202 of this station.

Use was also made of data* presented by the author in Bulletin 218 of the Rhode Island Agricultural Experiment Station. These data are the weights of all eggs from 591 White Plymouth Rocks during a period of at least three years.

EXPERIMENTAL

The changes in body weight, egg weight, and sexual maturity are shown in the form

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TABLE 2.—*Data for the White Plymouth Rocks used in this study*

Character	No. of birds	Unit	Mean
Age at first egg	577	days	297.6±1.312
Weight of first 10 eggs	577	grams	55.9± .193
Egg weight first year	577	grams	55.5± .191
Egg weight second year	388	grams	57.4± .253
Egg weight third year	208	grams	57.2± .355

of curves in Figure 1. The egg weights and body weights are grouped according to the age at which laying commenced. The average monthly egg weights of the birds and the average body weights are presented in Figure 1.

Table 1 shows data for mean egg weight and mean body weight for all Leghorns pictured in Figure 1, together with the number of birds included in each average.

There is a steady increase in egg weight for each group as they start production up to 11 months of age at which time both maximum body weight and maximum egg weight are attained. After 11 months of age there is no significant increase or decrease in egg weight for any of the groups until approximately 16 months of age. At this time there is more or less fluctuation in egg size which may be attributed both to the decrease in number of individuals available for study and to changes in temperature. Bennion and Warren (1932) have shown that variation in temperature will affect the weight of eggs.

It is clear from this study of egg weight that the time to obtain a measure of the first year's maximum egg weight is after the bird has attained its maximum body weight, which is approximately at 10 months of age. The curve for average egg weight from 11 to 16 months of age remains quite constant and measurements made during this period should give a reliable indication of inherent egg weight for the first year.

In Table 2 are presented statistics from a flock of White Plymouth Rocks reared at the Rhode Island State College. The average age at first egg for these birds is 297.6 days. This is exceedingly late maturing for White Rocks and these birds did not lay until maximum adult body weight was attained at 10 months of age. Table 3 demonstrates that in these late maturing birds the average weight of the first 10 eggs laid is highly correlated, .950 ± .002 with the average egg weight for the first year when these first 10 eggs are weighed at the time the bird has attained its adult weight which occurs at about 10 months of age. The egg weights for the second and third years are

TABLE 3.—*Coefficient of correlations for characters studied on White Plymouth Rocks*

Character	No. of birds	Coefficient of Correlation
Weight of first 10 eggs Egg weight first year	577	.950± .002
Egg weight first year Egg weight second year	388	.898± .006
Egg weight first year Egg weight third year	208	.877± .010
Egg weight second year Egg weight third year	208	.935± .005

also highly correlated with the first year's egg weight and with each other.

In Table 4 are presented correlations for the White Rocks only between the daughter's average yearly egg weight and the dam's average yearly egg weight, the dam's dam's egg weight and several other combinations of ancestors. These birds started from a group with fairly uniform breeding. From these a line with high egg weight and another line with low egg weight were then selected. The selection was highly effective and the mean egg weights of the high and low lines were soon distinctly different. The population is a mixture of the initial group and of five generations of birds selected for low egg weight and of six generations selected for high egg weight. This division of the population into distinct and non-interbreeding groups will explain the unusual highness of many of the correlations between relatives. Here it will be observed that there is a highly significant correlation between the daughter's average eggweight and the dam's average egg weight. This would suggest that if only those daughters which lay large eggs and whose dams laid large eggs also, are used for breeding purposes the tendency would be to increase the average egg size of the flock. The correlations between the daughter's average egg weight and the dam's dam's egg weight and between the daughter's average egg weight and the mother's sister's egg weight are also highly significant. Highly significant correlations also exist between the daughter's egg weight and the sire's dam's egg weight and between the daughter's egg weight and the father's sister's egg weight. It is of interest to note that the correlations on the sire's side are slightly higher than those found on the dam's side. Caution is suggested, however, in making the assumption that greater influence comes from the male side than from the dam's side. The correlations between the daughters and their maternal ancestry will include many different females while in the paternal ancestry the number of different females will be more restricted. Thus, the influence of a few males may exaggerate the results and unequal selection on the two sides of the pedigree might have caused the differences in the correlations.

TABLE 4.—*Coefficient of correlations for White Rocks between the daughter's average yearly egg weight and the dam's average yearly egg weight, the dam's dam's egg weight and several other combinations of ancestors*

Character	No. of birds	Mean	Standard Deviation	Coefficient of Correlation
Daughter's average egg weight Dam's average egg weight	591	55.3 ± .210 56.9 ± .199	7.6 ± .149 7.2 ± .141	.681 ± .015
Daughter's average egg weight Dam's Dam's average egg weight	517	55.2 ± .207 57.8 ± .219	7.0 ± .146 7.4 ± .155	.553 ± .030
Daughter's average egg weight Sire's Dam's average egg weight	550	55.4 ± .198 58.7 ± .264	6.9 ± .140 9.2 ± .187	.677 ± .015
Daughter's average egg weight Mother's Sister's average egg weight	481	54.9 ± .212 55.5 ± .181	6.9 ± .150 5.9 ± .128	.494 ± .023
Daughter's average egg weight Father's Sister's average egg weight	445	54.9 ± .221 54.7 ± .194	6.9 ± .156 6.1 ± .137	.609 ± .020

These correlations substantiate the findings of other investigators and indications from these data are that egg weight is highly inherited and that both the sire and dam probably contribute an equal influence in transmitting this character.

The data on White Plymouth Rocks indicate that the average egg weight for the first year is comparable with the second year's average egg weight when the mean egg weight for the first year is obtained after the birds have completed their full growth.

It is, of course, clear that the early sexually maturing birds at sexual maturity do lay smaller eggs than the later sexually maturing birds. The early sexually maturing birds lay a larger number of small eggs during the first year than the late sexually maturing birds. However, the early maturing birds are more efficient producers and in this study their maximum egg size at 10 months of age is equal to that attained by the later maturing birds. A. J. G. Maw and W. A. Maw (1932) suggest that it might be desirable to eliminate those birds which will not lay eggs of standard weight during the first year of laying as judged by the weighing of the first 10 eggs laid. One must use caution in discarding early sexually maturing birds because the weight of the first 10 eggs laid is too small. Birds that lay small eggs during their early laying period may be inherently able, when they attain their maximum body growth at 10 months of age, to produce eggs equal in weight to later sexually maturing birds.

The curves for body weight in Figure 1 show that the birds maturing sexually at approximately 120 days grow faster during the first six months than do any of the other groups. This increased growth velocity is manifested when the birds are about one week of age. The birds in this group, however, attain approximately the same maximum body weight at 10 months of age as do the later sexually maturing groups (see Table 5).

TABLE 5.—*Data on body weight classified according to the average days at first egg for White Leghorns used in this study*

Average age at 1st egg	No. of birds	Body weight in grams at 1st egg	Body weight in grams 10 months	Percent of body weight attained at age of first egg	Percent body weight of 120 day group attained by each group at four months
120	12	1273	1708	75	0
150	95	1334	1619	82	85.7
180	190	1476	1708	86	80.2
210	168	1590	1707	93	74.8
240	134	1681	1736	97	71.0
270	27	1711	1737	99	75.3
300	11	1718	1718	100	68.6

The curves for body weights for the other and later sexually maturing groups, with the exception of the curves for those birds laying at 270 days which are intermediate between the curves for 240 and 300 days, all show respectively a less rapid rate of growth depending on the average age that egg production commences. It would seem that these consistent differences in rate of growth manifested in each increase in age at first egg are not caused by chance alone or environmental differences. Each group has some birds that were raised in different years and under different environmental conditions.

The fact that all of these groups attain approximately the same maximum body weight at 10 months of age would suggest that there are inherent differences in rate of growth that operate independently of maximum adult weight. Further, the rate of growth manifested in all groups seems to be associated with sexual maturity.

Asmundson and Lerner (1933) point out

that there were genetic differences with respect to rate of growth within the strain of White Leghorns with which they were concerned. Schnetzler (1936) has shown that it is possible to select Barred Plymouth Rock fowl at eight or nine weeks of age which have inherent differences in body weight. Further, the chicks of the second seasons' hatch from the matings of the fast and slow growing stock show significant differences in growth rate. These results give further evidence that rate of growth is inherited. The published results of both Asmundson and Lerner and of Schnetzler do not include the complete growth curve for 10 months of age. This added material would establish whether the growth differences they found are confined only to the early phases of growth. Schnetzler's results would indicate that the material used in his study was not homogeneous for maximum adult body weight and that the differences found in early growth rate were probably correlated with final adult body weight attained at approximately 10 months of age.

Table 5 shows that the earliest sexually maturing birds weigh 31.4 percent more at four months of age than the latest sexual maturing birds. In all other groups, when compared with the earliest maturing birds, there is an appreciable difference in the average weight at four months of age. These data indicate the importance of early, rapid growth and that more attention should be given to the selection and breeding of birds which make the most rapid gains in weight during the first six months of age.

Waters (1934) has shown by the F_1 and F_2 hybrid offspring of a cross between White Legborns and Brahmas, that the average bird will not lay its first egg until about 90 percent of its ultimate adult weight at 10 months has been attained. Table 5 of this study shows that certain birds will lay before they attain 90 percent of their growth. The earliest maturing birds attained as low as 75 percent of their adult body weight at age of first egg. Others did not lay their first egg until they attained adult body weight. An average of

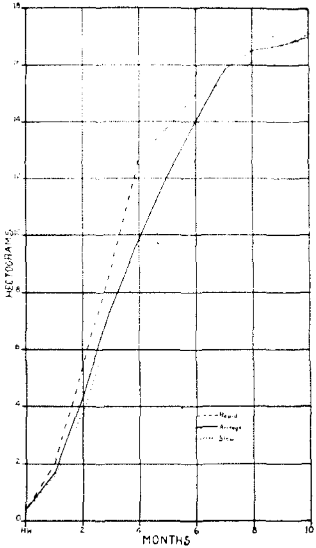

FIG. 2. Average Leghorn growth rates for all birds, for the most rapid laying at 120 days, and for the slowest group which commenced laying at 300 days.

all groups shows that 91 percent of the adult body weight is attained before laying commenced.

Figure 2 presents curves showing the average weights for all the Leghorns used in this study together with the growth curves for the most rapid growing group of birds which commenced laying at 120 days and for the slowest growing group which

commenced laying at 300 days. These curves demonstrate that the early laying birds are larger than the average of the entire group up to approximately six months of age. The birds which are the latest to begin laying are smaller than the average up to nearly 10 months of age. But all of these birds attain on the average the same weight at 10 months of age. At four months of age the rapid growing birds weighed 285 grams more than the average for all birds and 400 grams more than the slowest growing group. At three months of age the rapid growing group weighed 146 grams more than the average and 202 grams more than the slowest growing group. The rapid growing group maintained this accelerated growth from the time of hatching until six and one-half months of age. The slow laying group is slower growing from time of hatch until approximately 10 months of age.

If a breeder desires to select rapid growing birds as breeders the following procedure is recommended. A random sample of chicks should be selected at hatching time and monthly weights obtained for at least 10 months. These weights will establish a growth curve for a particular strain. All birds in the flock may be weighed at two, four, and six months of age. Those birds that are consistently larger than the average of the flock may be used for breeding purposes. Further, these birds should be earlier maturing sexually than the average of the flock.

It has been shown by many investigators that the earliness of sexual maturity is inherited and it is a logical assumption from this material that differences in rate of growth may be closely associated with this character. These data clearly show that the early sexually maturing birds grow more rapidly during the early phases of growth than do the late maturing birds.

The phenomenon that certain birds will grow faster than others during the first six months and that these differences are inherited, is of economic important to the poultry breeder and especially to the producer of market poultry. If an additional pound of weight can be placed on a fast growing early maturing bird at four or five months of age it will mean that the carcass is in a better condition for market purposes than a late maturing, slow growing bird.

A frequent assertion by practical poultry breeders has been that growth is retarded in early sexually maturing birds and that they do not attain an ultimate body weight equal to that of later sexually maturing birds of the same flock. Waters (1934) has shown that the ultimate body weight of a bird is not affected by the time of sexual maturity and the present investigation lends additional support to this finding.

SUMMARY

Maximum adult egg weight is attained when the bird reaches maximum adult body weight at approximately 10 months of age. After 11 months of age there is no significant increase or decrease in egg weight until about 16 months of age at which time there is more or less fluctuation in egg weight.

This study indicates that the time to obtain a measure of the first year's maximum egg weight is after the bird has attained its maximum body weight at approximately 10 months of age.

Measurements made during the eleventh to sixteenth months of age should give a reliable indication of the inherent egg weight for the first year.

Data on White Plymouth Rocks show that the average egg weight for the first year is highly correlated with the second year's average egg weight.

Birds maturing sexually at or about 120 days grow faster during the first six months

of age than do the later sexually maturing birds. All groups, however, attain approximately the same weight at 10 months of age.

It is suggested that inherent differences in rate of growth operate independently of maximum adult weight at 10 months of age. The rate of growth manifested in all groups seems to be associated with sexual maturity.

The ultimate body weight of a bird is not affected by date of sexual maturity and the early sexually maturing birds attain a maximum body weight at 10 months of age equal to that of the late sexually maturing birds.

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The Cannibalism Preventing Properties of Oats

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(Received for publication March 22, 1937)

CANNIBALISM presents a serious problem to the commercial poultryman. A general definition of cannibalism might be given as a vicious habit of picking toes, comb, vent, feathers, and other parts of the bird's body. Many preventive measures have been recommended involving management practices such as increasing the floor space per bird, more eating and drinking space, elimination of idleness, less confinement, cooler and better ventilated brooder houses, elimination of floor layers, use of more and better nests, and removal of injured or picked individuals. Emergency control measures of various types have been developed. Among these are the use of ruby red light as reported by Carver (1932), trimming beaks as reported by Kennard (1928), application of distasteful materials to the bird's body, and the use of vent protectors, beak guards, and blinders.

The feeding trials herein reported were started as the result of a prevalent belief on the part of Washington poultrymen that domestic yellow corn would increase the incidence of prolapsus of the oviduct. This popular belief was augmented by surveys conducted in Whatcom County, Washington, by the poultry extension agent. Two surveys seemed to indicate that the flocks fed heavily on corn had the greatest percentage of prolapsus occurring. The assumption of many at that time was that all cases of "pickouts" (death by vent picking) were the direct result of prolapsus.

TRIAL 1. PROCEDURE AND RESULTS

This trial was designed to determine whether high corn feeding increased the incidence of prolapsus of the oviduct. Four lots of 350 Single Comb White Leghorn chicks each, hatched on March 27, 1930,

TABLE 1.—*Formulae of starting rations fed in trial 1. (1930)*

Ingredient	Lot 1 control	Lot 2 corn	Lot 3 wheat	Lot 4 oats
Ground yellow corn	40	55		
Ground wheat	10		55	
Ground oat groats*	5			55
Wheat bran	15	15	15	15
Alfalfa leaf meal	5	5	5	5
Meat scrap	5	5	5	5
Fish scrap	5	5	5	5
Dried skimmilk	10	10	10	10
Bone meal	2	2	2	2
Ground oyster shell	2	2	2	2
Salt	1	1	1	1
Cod liver oil	1	1	1	1

* Changed to ground oats after first two weeks.

TABLE 2.—*Average body weights, days to maturity and initial egg size in trial 1 (1930)*

Factor	Lot 1 control	Lot 2 corn	Lot 3 wheat	Lot 4 oats
Weight at 8 weeks	477.7	480.8	464.8	539.6
Weight at 24 weeks	1388.0	1395.0	1363.7	1382.8
Weight at maturity	1465.7	1491.2	1462.9	1502.6
Days to maturity	174.0	177.3	179.3	180.5
Initial Egg weight (grams)	40.4	41.0	40.2	42.0

were fed the rations outlined in Table 1. The cockerels were removed on the bi-weekly weighing dates as soon as sex could be distinguished.

In order to conform to the recommended system of feeding practiced in Washington in 1930, the grain portion of the ration was increased each week until the 24th week according to the schedule of Carver (1929). In this experiment the grain was ground and added to the mash. Thus, the grain portion of the ration varied from 55 percent at the beginning of the trial to 85 percent at the end.

To determine the relative amounts of prolapsus occurring on the four lots fed the various grains, the pullets were housed together and individually trapped. Upon removal from the trapnest each bird was carefully observed for evidence of prolapsus. During the laying year, all birds were fed the Washington laying ration as reported by Miller (1930). No prolapsus was observed yet there was considerable mortality from cannibalism indicating that the problem was one of cannibalism rather than prolapsus as was the common belief of poultrymen.

Observations made during the growing period showed that at 14 weeks of age the birds in the corn and control pens had started to pick tail feathers. At 16 weeks of age there was an outbreak of tail picking in the corn pen. At 21 weeks of age the pullets in the corn pen had developed severe cannibalistic habits as previously reported by the authors (1930). Table 2 summarizes the growth, rate of maturity, and initial egg size of the four lots.

In view of the fact that there was more cannibalism in the corn fed birds in this trial, another experiment was outlined to see whether these results could be duplicated another year.

TABLE 3.—*Formulae of rations fed in trial 2 (1931)*

Ingredient	Lot 1 Control	Lot 2 corn	Lot 3 Wheat	Lot 4 oats
Ground yellow corn	25	70		
Ground wheat	25		70	
Ground oats	20			70
Alfalfa leaf meal	5	5	5	5
Dried skimmilk (1) (2)	10	10	10	10
Meat scrap (2)	5	5	5	5
Herring fish meal (2)	5	5	5	5
Ground oyster shell	2	2	2	2
Bone meal	2	2	2	2
Salt	1	1	1	1
Cod liver oil	1	1	1	1
Total	101	101	101	101

[1] After the first month 5 lbs. of dried skimmilk were replaced by ground grain.
[2] After the third month $6\frac{2}{3}$ lbs. of dried skimmilk, $1\frac{2}{3}$ lbs. of meat scrap and $1\frac{2}{3}$ lbs. of herring fish meal were replaced by ground grain.

TABLE 4.—*Summary of body weights, feed consumption, feed efficiency, days to maturity and egg weights of first five eggs in trial 2 (1931)*

	Lot 1 control	Lot 2 corn	Lot 3 wheat	Lot 4 oats
Weight at 8 weeks (grams)	459.8	474.7	460.0	533.0
Weight at 24 weeks (grams)	1503.6	1478.7	1374.1	1442.0
Weight at maturity (grams)	1536.6	1488.4	1479.9	1533.8
Days to maturity	164.5	162.1	165.6	174.0
Egg weight of first five eggs (grams)	40.4	40.0	39.7	42.8
Feed consumption for 24 weeks (lbs.)	20.6	18.4	18.6	21.6
Lbs. feed per lb. gain to 24 weeks	6.4	5.8	6.3	7.0

TRIAL 2. PROCEDURE AND RESULTS

Four lots of 400 Single Comb White Leghorn chicks each, hatched April 2, 1931, were fed the rations outlined in Table 3. The chicks were brooded and reared in confinement in pens 24 feet by 18 feet. They were allowed access at all times after the third week to a 6 feet by 24 feet wire sun porch. The cockerels were removed on the bi-weekly weighing dates as soon as sex could be distinguished.

Table 4 summarizes the body weights, feed consumption, feed efficiency, days to maturity, and egg weight of the first five eggs.

During the early growing period considerable mortality was experienced in the oat pen due to gizzard impaction with oat hulls. At the same time it was observed that many of the birds in the corn pen exhibited cases of perosis. Picking was not experienced in any lot until about 24 weeks of age. It was then noticed that some of the birds in the corn pen had been picked on the abdomen and around the vent causing injury and the removal of feathers. As the habit developed the abdomens became bare as the result of continuous feather picking.

At maturity each of the four lots were divided into two groups. In order to have birds of the same maturity in each pen, they were assigned to their respective pens alternately on the basis of the date of first egg. The slight differences between number of birds in pairs of pens in the laying phase was due to mortality experienced in the birds which came into lay before the end of the 24-week growing period. One group of each pair received the same ration they were reared on while the other group was fed the Washington laying ration as in the previous year.

Table 5 shows the results of the nine-month production phase of the trial. Table 5 shows that the pen 3 birds which received corn as the sole source of cereal during the growing period and which were continued on the same ration during the laying trial

TABLE 5.—*Summary of production, egg weight, and mortality by cannibalism for pullets entered in laying period in trial 2 (1931)*

	Lot 1 control		Lot 2 corn		Lot 3 wheat		Lot 4 oats	
	Pen 1 control	Pen 2 Wash. ration	Pen 3 corn	Pen 4 Wash. ration	Pen 5 wheat	Pen 6 Wash. ration	Pen 7 oats	Pen 8 Wash. ration
Pullets entered in laying period	66	71	78	69	53	56	39	41
Percent production	46.9	56.6	42.1	53.8	53.7	52.1	40.7	54.3
Egg weight (grams)	53.7	52.6	54.5	51.8	52.1	52.5	53.9	51.3
Percent mortality by cannibalism	16.7	21.1	41.0	21.7	17.0	25.0	7.7	4.9

TABLE 6—*Formulae of rations fed in trial 3 (1932)*

	Lot 1. control		Lot 2. corn	
	Starting ration	Developing* ration	Starting ration	Developing* ration
Ground yellow corn	25.0	25.0	72.5	82.5
Ground wheat	25.0	27.5		
Ground oats	22.5	30.0		
Dehydrated alfalfa	5.0	5.0	5.0	5.0
Dried skimmilk	10.0	3.33	10.0	3.33
Meat scrap	5.0	3.33	5.0	3.33
Herring fish meal	5.0	3.33	5.0	3.33
Oyster shell flour	1.0	1.0	1.0	1.0
Bone meal	1.0	1.0	1.0	1.0
Salt	.5	.5	.5	.5
Concentrated cod liver oil	.125	.125	.125	.125
Total	100.125	100.125	100.125	100.125

* The developing ration was fed starting with the 10th week.

had the greatest loss from cannibalism. The birds reared on oats had the lowest mortality from this cause.

The results in this trial verify the results of the first trial in that there was more cannibalism among the corn fed birds than in the other lots. Since cannibalism is known to be influenced by other factors than feeding and is habit forming it was deemed advisable to study the problem further.

TRIAL 3. PROCEDURE AND RESULTS

Two lots of 300 Single Comb White Leghorn chicks each, hatched March 24, 1932, were fed the rations outlined in Table 6. It was impossible to duplicate each lot of the previous year's trial due to lack of housing space. The chicks were brooded, reared, and housed in the laying period in the same manner as in trial 2. The cockerels were removed on the bi-weekly weighing dates as soon as sex could be distinguished. The results of the rearing period are given in Table 7.

As in the previous trial the corn-fed birds were affected with perosis in varying degrees. Feathering was good on the birds of both the corn and control groups and no picking was observed until late in the growing period. Between the 18th and 24th weeks five birds died as a direct result of cannibalism, and feather picking among the birds in the corn pen had become a general habit. Table 8 gives the results of the 12-month laying period.

Trial 3 again demonstrates that the birds which received corn as the sole source of cereal during the growing period and which were continued on the same ration during the laying period, had the greatest

TABLE 7.—*Summary of body weights, feed consumption, feed efficiency, days to maturity and egg weight of first five eggs in trial 3 (1932)*

	Lot 1. control	Lot 2. corn
Weight at 8 weeks (grams)	598.3	533.4
Weight at 24 weeks (grams)	1528.4	1513.8
Weight at maturity (grams)	1542.5	1520.6
Days to maturity	161.6	165.3
Egg weight of first five eggs (grams)	38.9	38.8
Feed consumption for 24 weeks (lbs.)	21.4	18.0
Lbs. feed per lb. gain to 24 weeks.	6 5	5.5

TABLE 8.—*Summary of production, egg weight, and mortality by cannibalism for pullets entered in laying period in trial 3 (1932)*

	Lot 1. control		Lot 2. corn	
	Pen 1 control	Pen 2 Wash. ration	Pen 3 corn	Pen 4 Wash. ration
Pullets entered in laying period	61	60	71	65
Percent production	63.3	66.0	58.0	65.9
Egg weight (grams)	53.1	52.3	52.5	51.5
Percent mortality by cannibalism	4.9	3.3	33.8	12.3

loss from cannibalism. It is apparent from the results of the preceding three trials that corn is either conducive to picking or is deficient in a factor which tends to satisfy the bird's cannibalistic urge. In order to determine more fully the picking preventive properties of the common poultry grains of this section a fourth trial was outlined.

TRIAL 4. PROCEDURE AND RESULTS

Eight lots of 68 fourteen-day-old sexed Single Comb White Leghorn pullets, hatched March 20, 1936, were fed the rations outlined in Table 9. From day-old to two weeks of age the chicks were fed the Washington State College commercial chick ration.

The ingredients were analyzed prior to mixing the rations and the rations were standardized to 16.0 percent protein, .80 percent phosphorus, and 1.6 percent calcium levels.

The chicks were brooded and reared in confinement in pens 12 feet by 18 feet. They were allowed access at all times after the third week to a 6 feet by 12 feet wire sun porch. At 24 weeks of age all healthy birds in each lot were placed in a laying house under similar conditions to those of the rearing period. The rations for each lot were the same in composition as those fed in the growing period. However, oyster shell was supplied ad libitum and a part of the grain portion of the ration fed as a whole grain scratch at the rate of eight pounds per 100 birds per day. Table 10 gives the results occurring in the growing period.

At six weeks of age, after being on the experimental ration for four weeks, practically all chicks in both corn lots showed a peculiar gait characterized by stiff-jointed, high stepping movements attributed to perosis. This condition was slightly

TABLE 9.—*Formulae of rations fed in trial 4 (1936)*

	Lots 1 and 5 wheat	Lots 2 and 6 corn	Lots 3 and 7 oats	Lots 4 and 8 barley
Ground domestic yellow corn		79.675		
Ground red wheat	80.875			
Ground western oats			80.875	
Ground California barley				77.775
Dehydrated alfalfa	5.0	5.0	5.0	5.0
Herring fish meal	4.9	5.5	4.9	6.6
Meat scrap	6.1	6.7	6.1	8.0
Oyster shell flour	2.0	2.0	2.0	2.0
Bone meal	.5	.5	.5	
Salt	.5	.5	.5	.5
Concentrated cod liver oil	.125	.125	.125	.125
Total	100.0	100.0	100.0	100.0

TABLE 10.—*Summary of body weights, feed consumption and feed efficiency in trial 4 (1936)*

	Wheat		Corn		Oats		Barley	
	Lot 1	Lot 5	Lot 2	Lot 6	Lot 3	Lot 7	Lot 4	Lot 8
Weight at 8 weeks (grams)	416.6	425.7	430.8	449.7	454.3	480.6	374.5	394.0
Weight at 24 weeks (grams)	1480.9	1510.6	1518.8	1579.9	1357.4	1578.1	1284.1	1391.9
Weight at maturity (grams)	1592.3	1610.3	1614.8	1623.9	1673.8	1682.9	1533.2	1592.1
Feed consumption for 24 weeks (lbs.)	19.6	19.6	18.0	17.8	20.9	23.3	18.6	20.3
Lbs. feed per lb. gain to 24 weeks	6.4	6.2	5.7	5.4	7.5	7.1	7.0	7.0

in evidence in the two barley pens. The condition was not in evidence in the greater part of the birds affected at the end of the growing period. There were a few cases, however, where leg deformities developed that were noticeable when the birds were transferred to the laying house.

No cannibalism of any type appeared until the pullets were 20 weeks of age. At this time a few cases of feather picking developed in pen 1. From this time on and before the end of the growing period feather picking had developed in all of the wheat, corn, and barley lots. There was no evidence of cannibalism of any type in the oat pens. Table 11 shows the degree to which cannibalism had progressed in the various pens at 24 weeks of age.

A study of this table shows that there was a rapid increase in cannibalism from the time it started to the 28th week. This cannibalism consisted almost entirely of picking feathers from the abdomens, base of tails, backs, thighs, and breasts. No picking had occurred in the oat pens up to this time. Between the 28th and 40th weeks there was some evidence of picked feathers on a few of the oat birds. In general, however, these birds presented a full feathered appearance. The fact that the birds were picked could only be determined by a close examination of the individual birds.

It will be noted from Table 11 that although the percentage of birds picked at 28 weeks was high in all except the oat pens, nevertheless the percentage of mortality by cannibalism was low in all pens.

The difference in the percentage of birds picked at 28 weeks of age between the oat pens and the rest of the experiment was highly significant statistically as determined by the analysis of variance method of Snedecor (1934), example 3. To be considered highly significant a value of F of

TABLE 11.—*Summary of cannibalism observations, days to maturity and egg weight first laying period in trial 4 (1936)*

	Wheat		Corn		Oats		Barley	
	Lot 1	Lot 5	Lot 2	Lot 6	Lot 3	Lot 7	Lot 4	Lot 8
Number birds housed	58	58	55	60	33*	54	52	58
Days to maturity	179.2	177.8	175.8	172.2	182.0	175.5	189.2	186.1
Egg weight first laying period	19.1	19.4	19.7	20.2	19.9	20.0	20.1	20.2
Per cent birds picked at 24 weeks of age	12.9	1.6	1.7	48.4	0	0	13.8	27.4
Per cent birds picked at 28 weeks of age	93.1	91.4	95.8	98.2	0	0	63.5	82.8
Per cent birds picked at 40 weeks of age	98.2	100.0	100.0	100.0	12.0	33.3	97.8	100.0
Per cent mortality from cannibalism to 40 weeks of age	0	0	0	3.3	0	0	0	0

* Heavy mortality occurred in Lot 3 during the growing period and was due chiefly to paralysis, coccidiosis and pendulous crops.

29.46 was required, whereas the F value obtained was 86.17.

GENERAL DISCUSSION

It will be noted from the results of the growing period in these feeding trials conducted in four different years that in every case the corn-fed birds during the late part of the growing period developed severe cannibalistic habits. This started with feather picking and in the two years, for which the complete laying house records are available, severe mortality occurred from cannibalism. In contrast very little picking of any type occurred in the oat-fed birds. Intermediate degrees of cannibalism were observed in the control, wheat, and barley in the years that these rations were fed.

It was observed that the feathering of the oat-fed birds was most abundant and that the corn-fed birds had feathers of a creamy color and oily appearance. Color of shanks and skin was in proportion to the amount of pigment in the grains, the corn birds having bright yellow shanks and yellow skin.

Perosis was observed in the corn pens each of the last three years. It was not observed in the other lots except in the barley lot in trial 4. The cases of perosis in the barley-fed birds were not as pronounced as those in the corn-fed birds.

The weight of the pullets at eight weeks of age was greatest on the oat-fed pens in every year in which the comparison was made. The weight of corn, wheat, and barley lots followed in that order. At 24 weeks of age the corn-fed birds were heaviest, followed in order by oats, wheat, and barley. At maturity or first egg the oat-fed birds were heaviest, followed by corn, wheat, and barley.

Wilcke (1936, 1937) reported that rations consisting of ground whole oats as the sole source of cereal grain were more satisfactory from the standpoint of growth and feathering than similar rations with corn or wheat as the cereal source. He confirmed the findings of other workers that perosis did not develop in birds fed oats while this deformity was present in the birds fed rations composed of corn as the sole cereal. Wilgus et al. (1936) found manganese to be effective in preventing perosis.

Since perosis was observed in the birds on the corn and barley rations in the trials reported in this paper and not in the birds fed oats or wheat, the grains fed in trial 4 were analyzed quantitatively for manganese. The manganese contents in milligrams per 100 grams of grain were found to be: oats 4.66, wheat 2.91, barley 1.19, corn 0.38. This difference in manganese content indicates that manganese could be responsible for the prevention of perosis in the birds in the oat and wheat pens. Further work is in progress to determine whether manganese or other nutritional factors are responsible for the cannibalism preventing properties of oats inasmuch as the oats analyzed highest in manganese and the corn lowest.

It might be concluded from the results of the trials herein reported that oats as the sole grain would make an ideal growing ration, however, we must not overlook the fact that oats caused considerable difficulty with gizzard impactions in the young chicks and that there seemed to be a greater tendency for pendulous crops to develop particularly in the last trial. It is also true that from the standpoint of feed efficiency the oat-fed birds were poorest. Initial egg weight was somewhat larger in the oat birds, doubtless the result of slower maturity and greater body weight.

The results of these trials suggest the possibility that cannibalism is a result of an unsatisfied appetite which in turn is caused by a deficiency of some nutrient.

SUMMARY

Oats fed as the sole cereal in a ration for growing and laying pullets consistently and significantly reduced cannibalism be-

low that experienced on rations containing corn as the sole cereal. The four trials were conducted in four different years with different lots of feed each year. The growth value of the grain as determined at eight weeks showed oats first in every comparison followed by corn, wheat, and barley, respectively.

The body weight at first egg was in the same order although the corn-fed birds were heaviest at 24 weeks of age.

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Effects of Light, Soybean and Other Diet Supplements on Seasonal Hatchability and Egg Production

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(Received for publication April 10, 1937)

INTRODUCTION

SOYBEAN *meal is widely used as a* protein concentrate in the diet of laying fowls. Its value for egg production is not disputed. Hatchability of eggs produced by birds receiving diets containing soybean meal, at least that made from some varieties of soybeans, probably depends on the kinds and amounts of animal protein concentrates included in the same diet. Direct sunlight is a very important factor in the production of hatchable eggs.

Byerly, Titus, and Ellis (1933) showed that meal made from the Mammoth Yellow variety of soybeans was inadequate for the production of eggs of high hatchability by semi-confined birds that received an all plant-source diet containing about 20 parts per 100 of the soybean meal. Subsequent studies have shown the Illini variety of soybean to be deficient in the same manner. Nestler, Byerly, Titus, and Ellis (1936) showed that the deficient factor in the diet used was not vitamin G. The deficient factor was found to be abundant in dried pork liver and in green range but not in whey.

Diets used in previous soybean experiments at this station all contained 2 percent of high-grade medicinal cod liver oil. However, unusually low winter hatchability and lower hatchability of eggs from birds confined behind glass than of eggs from birds receiving direct sunlight, indicated the desirability of tests with various vitamin D levels. In order to assess the rôle of light, season, and vitamin D in soybean deficiency, an experiment was organized at the National Agricultural Research Center, Beltsville, Maryland, and conducted from October, 1934, to August, 1935, inclusive.

MATERIALS AND METHODS

Twelve pens of Single Comb Rhode Island Red pullets housed in a long house with physical conditions and management as described by Byerly, Titus, and Ellis (1933), except as noted, were used. Each pen contained 25 females at the beginning of the experiment. Single Comb Rhode Island Red cockerels were used and each was shifted from one pen to the next twice a week.

The basal diet used consisted of about 71 parts of the basal feed mixture described by Titus, Byerly, Ellis and Nestler (1936), 20 parts of expeller process meal made from Illini soybeans, steamed bone meal and limestone sufficient to adjust the Ca:P ratio to 2.5:1, and 0.5 percent each of salt and of anhydrous sodium sulphate. The basal feed mixture consisted of ground yellow corn 500, wheat bran 245, rolled oats

TABLE 1.—*Effects of various diet supplements on hatchability*

Pen	Diet supplements	Birds	Fertile eggs set	Chicks hatched	Average hatchability	Calculated hatchability
		Number	Number	Number	Percent	Percent
124	Carotene Artificial light	16	167	79	44.8± 5.2	46.9
125	All beef scrap 2A Carotene Artificial light	11	63	45	66.8± 8.2	66.3
126	Cod liver oil 2% Artificial light	19	541	317	52.3± 5.7	49.2
127	All beef scrap 2A Cod liver oil 2% Artificial light	20	893	650	68.3± 3.8	68.6
128	Sunlight Carotene	20	808	519	63.6± 5.7	61.0
129	Sunlight Cod liver oil 2%	21	1,495	950	61.9± 4.1	63.3
130	All beef scrap 2A Sunlight Cod liver oil 2%	20	1,240	1,029	82.8± 1.9	82.7
131	All beef scrap 2A Sunlight Carotene	20	828	682	80.4± 2.2	80.3
132	Cod liver oil 3% Artificial light	18	1,103	656	57.2± 5.7	—
133	Cod liver oil 4% Artificial light	18	648	333	49.3± 6.7	—
134	Red light Carotene	10	119	33	35.6±10.7	—
135	Red light Cod liver oil 2%	16	665	299	51.9± 5.9	—

150, and alfalfa leaf meal 55, parts by weight, respectively.

Positive control pens received the basal diet described, with 20 parts by weight of special all-beef scrap No. 2a, described by Titus, Byerly, Ellis, and Nestler (1936), added to each hundred parts by weight of the basal diet. The steamed bone meal and limestone were adjusted to give a Ca:P ratio of 2.5:1 in the finally compounded diet. Item 2a contained 10 percent of liver and was shown in the paper just cited to be adequate for the production of eggs of high hatchability throughout the year when fed at a 20 percent level as a supplement to the basal feed mixture used in the present experiment and fed to semi-confined birds.

Supplements to the diets described are listed in Table 1. The pens which received ordinary artificial light were kept in pens from which daylight was excluded by means of heavy muslin and were lighted 12 hours daily by means of ordinary 100 watt bulbs. The red light pens were lighted with 500 watt red bulbs 12 hours daily and the win-

dows were covered with red muslin. The daylight pens were provided with small, cement floored runways; sunlight was admitted through large openings on the south side of each pen.

The carotene used was a highly concentrated commercial carotene product and was fed at a level, calculated from rat tests, to be equivalent in vitamin A potency to the 2 percent cod liver oil used in other pens. The cod liver oil was a high grade medicinal oil. Rat and chick feeding tests showed that it contained more than 85 I. U. per gram.

PRESENTATION OF DATA

In Table 1 are presented the data showing average hatchabilities with respect to the various dietary modifications imposed. The average hatchabilities and their standard errors were computed by the method of Hendricks (1935). They are the weighted average hatchabilities of the eggs laid by the several females in each pen.

Pens 124, 126, 132, and 133 comprise a vitamin D level series which received 0, 2, 3 and 4 percent of cod liver oil, respectively, and 12 hours daily of artificial light. There are no statistically significant differences among the average hatchabilities of the eggs from the birds in these pens. Pens 134 and 135 received 0 and 2 percent of cod liver oil, respectively, with 12 hours daily of red artificial light. The average hatchabilities of the eggs from the birds in these pens show no statistically significant differences either from each other or from the data for pens 124, 126, 132, and 133. Eggs from pens 124 and 134 did drop in hatchability to a very low level after January but the drop in hatchability accompanied an almost complete cessation in egg production.

Pens 125 and 127 were positive control pens which received 0 and 2 percent of cod liver oil, respectively. The difference in average hatchabilities between the eggs from birds in these pens was obviously not statistically significant. The average hatchability of eggs from birds in pen 125 was significantly greater than that for pen 124, the difference being 22.0 ± 9.7 or 2.13 times its standard error, and that for pen 134, the difference being 31.2 ± 13.5 or 2.31 times its standard error. The average hatchability for pen 127 is significantly greater than that for pens 124, 126, 133, 134, and 135, the ratios of the difference to their respective standard errors being 3.63, 2.34, 2.47, 2.90, and 2.34:1, respectively.

Pens 129 and 128, which received direct sunlight with and without cod liver oil, respectively, did not differ from each other significantly in hatchability. This is also true for pens 130 and 131, positive control pens which received direct sunlight with and without cod liver oil, respectively.

The data on hatchability for pens 124-131, inclusive, were subjected to analysis by the method of least squares to determine quantitatively the effects of direct sunlight

TABLE 2.—*Value of dietary factors for hatchability when used as supplements to the basal diet. These values are strictly additive*

Dietary factors	Calculated values (percent)	Standard errors
Basal plus carotene	46.9	±1.44
Basal plus 2 percent cod liver oil	49.2	±1.35
Direct sunlight	14.1	±1.28
All beef scrap 2A	19.4	±1.26
Difference—2 percent cod liver oil and carotene	−2.4	±1.57

and all-beef scrap 2a and the relative effects of carotene and 2 percent of cod liver oil. Absolute values for the two latter factors and a value for the basal diet alone could not be obtained because no pen was fed the basal diet only. The results of the analysis are given in Table 2. Each of the values except that for the difference between cod liver oil and carotene was found to be statistically significant.

The calculated values given in the last column of Table 1 were obtained by adding together the appropriate values in Table 2. Thus, for example, the calculated percentage hatchability for pen 125 which received the basal diet with supplements of carotene and all-beef scrap 2a was obtained by adding together the following values taken from Table 2:

$$46.9\% + 19.4\% = 66.3\%.$$

Likewise, the calculated percentage hatchability for pen 130 which received the basal diet with supplements of cod liver oil, all-beef scrap 2a, and direct sunlight was obtained as follows:

$$49.2\% + 19.4\% + 14.1\% = 82.7\%.$$

The agreement between the observed and calculated values is exceedingly close.

Since the administration of various amounts of cod liver oil and of red light instead of ordinary artificial light induced no significant improvement in average hatchability, data for pens differing only in these factors have been grouped together in Table 3. The confined pens which received no cod liver oil are segregated because, as pointed out above, the average values are largely based on data from eggs laid during the first four months of the experiment.

The data in Table 3 show that the eggs from the positive control pens which received direct sunlight hatched significantly better than any of the others. The eggs from the soybean meal pens which received

TABLE 3.—*Dietary supplements and hatchability*

Group	Supplement	Pens	Average hatchability (percent)	Standard error of difference	Ratio of difference to standard error of difference[1]
1	Carotene Artificial light	124, 134	43.1±4.9	1−2=9.6 1−3=5.8 1−4=6.2	2.47 1.71 4.06
2	Carotene Artificial light All beef scrap 2A	125	66.8±8.2	2−3=8.7 2−4=9.6 2−6=8.3	1.58 0.16 1.90
3	Cod liver oil Artificial light	126, 132 133, 135	53.0±3.1	3−4=4.9 3−5=4.6	3.12 2.04
4	Cod liver oil Artificial light All beef scrap 2A	127	68.3±3.8	4−5=5.1 4−6=4.0	1.16 3.58
5	Carotene or Cod liver oil Direct sunlight	128, 129	62.4±3.4	5−6=3.6 5−2=8.9 5−1=6.1	5.61 0.49 3.17
6	Carotene or cod liver oil Direct sunlight All beef scrap 2A	130, 131	82.6±1.1	6−3=3.3 6−1=5.0	8.97 7.90

[1] A ratio of difference: Standard error of D of 2 indicates a probability of about 1 in 20 and of 3, about 1 in 100.

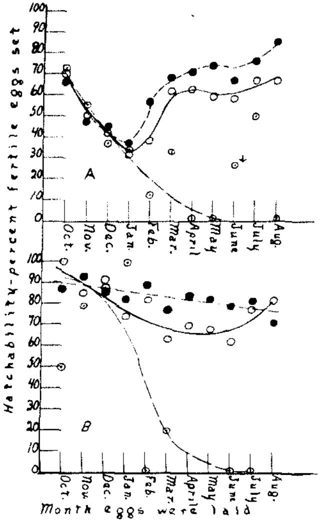

FIG. 1. Seasonal effects on hatchability of soybean meal, sunlight.

A. Eggs from birds receiving soybean meal diet.
● Eggs from birds receiving direct sunlight.
○ Eggs from strictly confined birds receiving cod liver oil.
⊙ Eggs from strictly confined birds without cod liver oil.
1. Anomalous production, probably due to an *accident of management.*
B. Eggs from birds receiving positive control diet.
● Eggs from birds receiving direct sunlight.
○ Eggs from strictly confined birds receiving cod liver oil.
⊙ Eggs from strictly confined birds without cod liver oil.

direct sunlight hatched better than eggs from the strictly confined soybean pens.

SEASONAL HATCHABILITY

Figure 1A shows hatchability of eggs laid during each month of the experiment by birds receiving the soybean meal diets (1) with direct sunlight, (2) in strict confinement with cod liver oil, and (3) in strict confinement without cod liver oil. Eggs from groups (1) and (2) dropped in hatchability to a low value of about 35 percent in January, then rose in hatchability quite sharply. Hatchability of eggs from the direct sunlight group was distinctly better than that of eggs from the strictly confined group from December to the close of the experiment. Eggs from the strictly confined group which received no cod liver oil dropped in hatchability to a value of zero percent for the very few eggs laid in April and May. Hatchability for the eggs from this group rose anomalously in June and July. Probably some accident in management occurred. A concurrent increase in egg production occurred in pen 124. Eggs from pen 134 showed no rise in hatchability nor in number during June and July.

Figure 1B shows the hatchability of eggs laid each month by birds receiving the positive control diet with direct sunlight, in strict confinement with cod liver oil and in strict confinement without cod liver oil. The group which received direct sunlight showed essentially no seasonal variation in hatchability. There was a gradual decrease from a value of about 90 percent at the beginning of the experiment to a value slightly below 80 percent at the close. The confined group which received cod liver oil showed a sharper decline during the course of the experiment with a final rise in hatchability during July and August. Hatchability of the eggs from the confined group which received cod liver oil was lower than that from the group which received direct sunlight from January to July. Hatchability of eggs from the confined group without cod liver oil dropped sharply after January. Only a few eggs and no chicks were obtained after March.

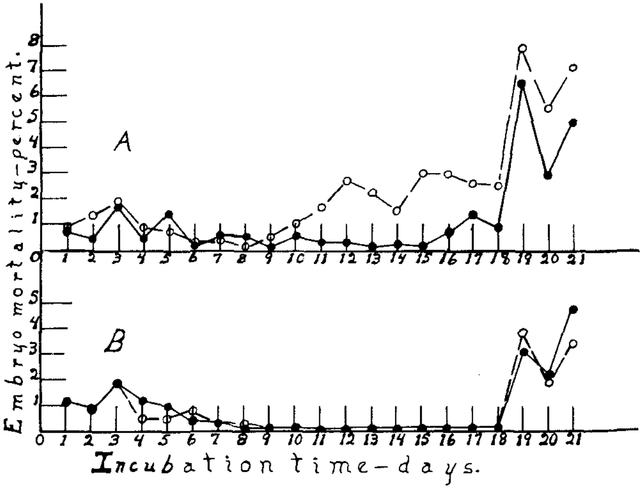

FIG. 2. Seasonal effects on embryonic mortality of soybean meal.

A. Eggs from birds receiving soybean meal and direct sunlight. O—Fall and winter; 817 fertile eggs set, 52.6 percent hatch. ●—Spring and summer, 739 fertile eggs set; 75.8 percent hatch.

B. Eggs from birds receiving positive control diet and direct sunlight. O—Fall and winter, 637 fertile eggs set; 82.9 percent hatch. ●—Spring and summer, 715 fertile eggs set; 82.0 percent hatch.

EMBRYONIC MORTALITY

Figure 2A shows the daily embryonic mortality expressed as a percentage of fertile eggs set for the soybean meal group which received direct sunlight. Curve 1 shows the mortality during the fall and winter months, curve 2 that for the spring and summer months. The high second week mortality shown in curve 1 is characteristic of eggs from birds fed all plant source diets in semi-confinement, as shown by Byerly, Titus, and Ellis (1931). Curve 2 shows that second week mortality fell to an approximately normal value and third week mortality was greatly reduced during the spring and summer months. Data for the strictly confined birds which received cod liver oil showed high second week mortality throughout the experiment. Second week mortality for eggs from the confined birds with cod liver oil was 10.6 percent during fall and winter, 8.5 percent during spring and summer. Third week mortality fell from 30.3 percent during fall and winter to 20.8 percent during spring and summer.

Figure 2B shows daily embryonic mortality for eggs from the positive control group which received direct sunlight. The curve for the fall and winter period is practically identical with that for spring and summer.

EGG PRODUCTION

Percentage production, adjusted for number of days birds in each pen lived, by

TABLE 4.—*Effects of dietary supplements on relative egg production*

Pen	Supplements	Egg production (percent; adjusted for days lived)	Standard error
124	Carotene 12 hours artificial light	7.18	3.33
125	Carotene All beef scrap 2A 12 hours artificial light	10.01	4.33
126	2 percent cod liver oil 12 hours artificial light	18.66	3.32
127	2 percent cod liver oil All beef scrap 2A 12 hours artificial light	21.46	3.25
128	Carotene Direct sunlight	28.78	3.53
129	2 percent cod liver oil Direct sunlight	34.62	3.28
130	2 percent cod liver oil Direct sunlight All beef scrap 2A	36.51	3.43
131	Carotene Direct sunlight All beef scrap 2A	30.20	3.31
132	3 percent cod liver oil 12 hours artificial light	22.99	3.33
133	4 percent cod liver oil 12 hours artificial light	19.53	3.33
134	Carotene 12 hours red light	10.35	3.34
135	2 percent cod liver oil 12 hours red light	26.14	3.58

means of covariance analysis, is given for each pen in Table 4. Egg production was unsatisfactory in all the pens. The birds used in the experiment were reared from chicks obtained from a large commercial hatchery and their genetic constitution for egg production was probably not good. Further, though the mean number of days lived, about 308, was over 90 percent of that possible (336), there was a good deal of chronic neurolymphomatosis and this undoubtedly curtailed egg production in all the pens.

Relative production was significantly greater in each pen which received direct sunlight than in the other pen of the pair which was strictly confined. Production in pen 129 exceeded that in pen 126 by 15.96 $\pm$ 4.67 percent; in pen 130 exceeded that in pen 127 by 15.05 $\pm$ 4.62 percent; in pen 131 exceeded that in pen 125 by 20.19 $\pm$ 5.45 percent and in pen 128 exceeded that in pen 124 by 21.60 $\pm$ 4.67 percent.

The pens which received all beef scrap 2A, pens 125, 127, 130, and 131, exceeded their paired pens, *124*, *126*, *129*, and *128*, respectively, in each case. However, the dif-

ferences were in no case significant, the difference between pens 125 and 124 being only 2.83 ± 5.37; that between pens 127 and 126 being only 2.80 ± 4.64; that between pens 130 and 129 being only 1.89 ± 4.74 and that between pens 131 and 128 only 1.42 ± 4.84.

The confined pens which received 2 percent cod liver oil laid at a significantly greater rate than the confined pens which received carotene. The difference between pens 124 and 126 was 11.48 ± 4.70 percent, between pens 125 and 127, 11.45 ± 5.42 percent and between pens 134 and 135, 15.79 ± 4.89 percent. Pens 132 and 133 which received 3 percent and 4 percent of cod liver oil, respectively, laid at rates not significantly different from the rates in pens 126, 127, and 135 which received 2 percent of cod liver oil. The two pens which received cod liver oil and direct sunlight, pens 129 and 130, laid at an insignificantly greater rate than their paired pens, 128 and 131, which received carotene. The difference between pens 128 and 129 was 5.84 ± 4.82 percent and that between pens 130 and 131 was 6.31 ± 4.77.

DISCUSSION

The data presented confirm the finding of Byerly, Titus, and Ellis (1933) that at least some soybean meals are inadequate for the production of eggs of high hatchability when fed at a level of 20 percent of the diet as the sole protein concentrate. Research reported in the paper cited and other work at the National Agricultural Research Center indicated that the Mammoth Yellow variety of soybean was very unsatisfactory as a sole protein supplement while the Wilson variety supported the production of eggs of normal hatchability. The nature of the deficiency is apparently complex. The seasonal variability must, in the present experiment, be due to an indirect effect. Strictly confined birds and those with direct sunlight showed approximately the same seasonal variability which was absent in the group receiving the positive control diet.

Neither quality of light nor hours of light can be responsible for this variability. Environmental temperature may have affected the birds' efficiency in transferring factors available in minimal amounts in the soybean meal to their eggs. It is more probable that the normal peak in the physiological efficiency of the hen, which is reflected in increased egg production during the spring months, increased the efficiency of transfer of necessary materials from diet to egg.

There is very good evidence that direct sunlight distinctly increased hatchability of eggs produced by birds receiving it over the hatchability of eggs produced by the strictly confined birds. The data do not indicate that this effect of sunlight was due to vitamin D formation by the birds since additional cod liver oil above 2 percent failed to improve hatchability of eggs laid by the confined birds. In the present state of our knowledge, it seems conservative to suppose that sufficient vitamin D for maximum egg production is also sufficient for maximum hatchability. In the present experiment, sunlight may have increased the efficiency of the birds and thus had a similar effect to the seasonal one and have been superposed upon it.

In addition to the seasonal and sunlight effects there was present a true deficiency in the soybean meal used. Even in the spring and summer periods, the hatchability of the eggs from the positive control pens receiving direct sunlight exceeded that from the soybean meal pens receiving direct sunlight in each month except August and eggs from the corresponding positive control pen, strictly confined, with cod liver oil, exceeded in hatchability the eggs from the

strictly confined soybean meal pens with cod liver oil, in each of the spring and summer months. This deficiency was discussed by Nestler, Byerly, Titus, and Ellis (1935), who showed that it is satisfied by some factor present in liver or green range and that the factor is not vitamin G. This finding has been tentatively confirmed by Smith (1936), and Heiman, Carver, and St. John (1936).

The fact that cod liver oil enables confined birds to produce more eggs than birds receiving no vitamin D supplement is too well known to merit discussion.

In the experiment reported, birds receiving direct sunlight laid significantly more eggs than their control pens which were confined even when adequate amounts of cod liver oil were given.

CONCLUSIONS

Expeller process soybean meal made from the Illini soybean is deficient in some factor necessary for hatchability.

Illini soybean meal, when fed as the sole protein concentrate at a 20 percent level, causes very low winter hatchability.

Direct sunlight increases hatchability of eggs laid by birds receiving Illini soybean meal through some other mechanism than vitamin D.

Egg production was significantly greater *in pens which received direct sunlight than* in confined pens adequately supplied with cod liver oil.

These results indicate that the Illini bean may be intermediate in deficiency between the highly unsatisfactory Mammoth Yellow variety and the fairly adequate Wilson variety used in former experiments.

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A Note on the Incidence of *Syngamus Trachea* in Turkeys, with Observations on Nodules Caused by this Parasite

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(Received for publication April 13, 1937)

INTRODUCTION

In order to collect data on the prevalence of *Syngamus trachea* in turkeys reared in the general vicinity of Washington, D.C., and to obtain material for use in experiments, examinations were made of the tracheas of a large number of turkeys killed at a poultry market in Washington, D.C., during the months of November and December, 1936. Although nothing definite is known as to the age of these birds, it is believed that most, if not all, of the birds examined were under one year of age and probably not over nine months, since they were killed primarily for the Thanksgiving and Christmas trades.

Entire tracheas were obtained in most cases. A few incomplete tracheas were present in the lots obtained, but as these usually lacked only the anterior portion, the percentage of infestation recorded in this paper probably was not greatly affected, since the greatest number of worms were observed to be attached to the trachea a short distance anterior to its bifurcation into the two main bronchi; in a few cases, worms were found attached near the middle of the trachea. There is sufficient evidence to show that gapeworms may attach to any part of the trachea in experimentally infested birds, especially when the test animals are given large doses of embryonated eggs and larvae. However, under natural conditions, the birds usually pick up only a few eggs or larvae at a time and the lower half of the trachea seems to be the usual site of attachment in such cases.

INCIDENCE OF INFESTATION

The examinations made on various dates, together with the incidence of infestation are summarized in Table 1.

An examination of the data presented in Table 1 shows that the total number of tracheas examined during the two months was 936, and out of this number 138 (14.7 percent) contained gapeworms.

Counting the paired male and female as two worms, 75 of the 138 tracheas infested with gapeworms contained 2 worms, 30 contained 4 worms, 18 contained 6 worms, 8 contained 8 worms, 2 contained 10 worms, 3 contained 12 worms, 1 contained 14 worms, and 1 contained 46 worms.

Out of a total number of 679 turkey tracheas collected by Ransom and Avery from a poultry sales house in Washington, D.C., and examined during the months of December, 1916, January and February, 1917, and March and November, 1918, 153 (22.5 percent) contained gapeworms or "lesions" of gapeworms. In the first series

of tracheas collected by Ransom and Avery (386 examined in December, 1916, and January and February, 1917), gapeworms were recovered from 89, and "characteristic lesions" were observed in three tracheas, making a total of 92 (23.8 percent) infested tracheas. In the second series (115 examined in March, 1918), gapeworms were observed to be present in 17 tracheas, and a "gapeworm lesion" in one trachea, making a total of 18 (15.7 percent) infested tracheas. In the third series (178 examined in November, 1918), gapeworms were found in 43 (24.2 percent) of the tracheas. Ransom (1921) stated that throughout the three series of examinations "incomplete tracheas were the rule" and that the percentage of infestation would probably have been higher if entire tracheas had been obtained in all cases. This percentage of infestation reported by Ransom (1921) is approximately 7.8 percent higher than that reported in the present paper for the months of November and December, 1936, thus indicating that gapeworms were more prevalent in turkeys reared in the general vicinity of Washington, D.C., at that time than in the fall of 1936 when the present observations were made. Whether this incidence has been the result of a decline in gapeworm disease in this region from year to year as the result of improved methods of rearing turkeys, or the result of some unfavorable climatic conditions existing prior to 1936, or both, is not certain. Regardless of the cause of the difference in the percentage of incidence of infestation during the two periods, it is apparent that gapeworm infestation is not at present as great a problem for poultrymen in this section of the United States as it has been in the past. This statement is substantiated by observations made on a recent visit to a number of farms in nearby Maryland and Virginia on which turkeys are being raised. A number of the farmers and poultrymen visited have adopted improved methods and are spending considerable money and time to improve the sanitary conditions of their poultry areas. The larger poultry raisers had apparently fully realized the danger of rearing turkeys and chickens together on the same ground, a fact first shown by Ransom (1921) and more strongly emphasized by Hall (1928), and had, therefore, altered their previous practices so as to eliminate, at least partially, this danger.

NODULE FORMATION CAUSED BY SYNGAMUS TRACHEA

Ransom (1921) referred to "characteristic lesions marking the former location of gapeworms" in the tracheas of turkeys obtained from a poultry market in Washington, D.C., but did not describe the lesions in detail. Clapham (1935) reported the oc-

TABLE 1.—*Showing the incidence of infestation of turkey tracheas with gapeworms during the months of November and December, 1936*

Date	No. of tracheas examined	No. of tracheas infested	Percentage of infestation
October 31	101	9	8.9
November 4	37	3	8.1
November 7	105	18	17.1
November 11	78	4	5.1
November 14	63	11	17.4
November 19	65	0	0.0
November 21	96	27	27.8
November 24	50	6	12.0
December 3	114	10	8.7
December 24	226	50	22.1

currence of nodules in the tracheas of pheasants dying of gapeworm disease from 10 to 14 months after natural infection. According to Clapham, deaths of the birds were due to asphyxiation caused by the enormous development of the nodules which, in some cases, had reached the size of a "small pea." Clapham also reported that "small red abraded areas with a tiny papilla" had often been seen in tracheas of chickens but since the chicken "loses its infection within a short time, little opportunity is afforded for further development."

The examination of turkey tracheas referred to in this paper showed that nodules resulting from gapeworm infestation are apparently of fairly common occurrence in these birds and indicates also that the host-parasite relationship in this instance is not adjusted as perfectly as some authors have reported.

It was observed that as each pair of worms was removed from the trachea with a pair of forceps, the head of the male worm was firmly attached to the center of a nodule and that, in many cases, it was entirely surrounded by the nodular tissue, and that it was often difficult to remove the worm without leaving the head attached. This observation suggests that the male worm may remain attached permanently to the wall of the trachea and may serve as an anchor for the female worm which attaches and detaches periodically for the purpose of finding a new and more abundant supply of blood on which to feed. The unequal size of the two sexes and the distinctly lighter red color of the male worm also indicate that the male does not require for its development the same amount of blood as does the female worm, and therefore, it is not necessary for the male to move from place to place in search of a more abundant food supply.

The nodules, as seen in the freshly opened trachea, were firm in texture and of about the same color as the adjacent cartilaginous tissue. An occasional nodule showed a slightly reddish tinge.

HISTOPATHOLOGICAL STUDY OF NODULE

Serial sections of a nodule containing the embedded head of a male worm were submitted to Dr. G. T. Creech of the Pathological Division, Bureau of Animal Industry, for study. His report is given below:

"The nodule resulting from the irritation due to the presence of the parasite was largely lymphoid in character. Portions of the head of the parasite could be seen embedded very near, or in contact with the tracheal cartilage. At the point of contact there was destruction of the perichondrium and also degeneration, with some evidence of dissolution of the tracheal cartilage. Mixed with the lymphoid cells of the nodule were leucocytes, large mononuclear cells, fibroblasts and epitheloid cells. Also a considerable number of well-formed giant cells were found just external to the zone of necrosis which immediately surrounded the parasite. The mucosa covering the nodule showed thickening and desquamation of epithelium. There was some proliferation of fibrous connective tissue, and the blood supply was furnished by a number of capillaries scattered through the nodule."

SUMMARY

As a result of an examination of 936 turkey tracheas collected at one of the poultry markets in Washington, D.C., the percentage of infestation was found to be approximately 14.7 percent, or about 7.8 percent lower than that reported by Ransom (1921) for the same territory. However, inasmuch as Ransom stated that a large number of incomplete tracheas were examined, it is likely that the difference in the percentages of infection of the two examinations might have been greater than

that indicated above. The lower percentage of infestation determined for the year 1936 would appear to indicate that gapeworms in turkeys were a more serious problem to the poultryman a few years ago than during the past year.

Nodules in the tracheas of turkeys resulting from gapeworm infestation are apparently of fairly common occurrence. Each nodule was observed to be the result of the attachment to the wall of the trachea of the head of the male worm which, in many cases, was deeply embedded in the nodular tissue so that it was difficult to remove the male worm without leaving the head in the nodule. This observation has suggested that the male worm may remain attached during most, if not all, of its parasitic life in the trachea of the turkey and may serve as an anchor for the female worm which apparently attaches and detaches periodically in order to obtain food. A histopathological study of a nodule containing the deeply embedded head of a male worm was made.

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Studies in Coccidiosis in Chickens

CALCIUM CARBONATE ADDITIONS AND COCCIDIA

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(Presented at Annual Meeting, August, 1936; received for publication August 14, 1936)

EXPERIENCE at the Wisconsin Experiment Station has shown that when chicks are hopper-fed chick size limestone grit or chick size oyster shell the consumption will vary from 1 to 4 percent of the ration. Chicks receiving an insufficient amount of vitamin D will consume more calcium carbonate grit than will those having access to direct sunshine or those receving an ample amount of vitamin D as supplied by cod liver oil or other vitamin D oils.

Halpin (1926) reported that chicks reared inside, fed rations containing and addition of approximately 3.6 percent limestone, weighed 509 grams at ten weeks whereas those receiving no limestone averaged only 353 grams. Later experience, however, demonstrated that 2 percent of a calcium carbonate carrier in the usual chick ration was sufficient.

Herrick, Ott, Halpin, and Holmes (1935) reported preliminary results which indicated that rations, high in calcium carbonate, increased the susceptibility of chickens to coccidiosis.

The experiments reported here are a continuation of the preliminary studies mentioned above. The Single Comb White Leghorn chicks used in this study were from stock maintained at the Wisconsin Agricultural Experiment Station. The chicks were placed in sterilized brooders and were fed "sterilized"[1] rations under conditions that made coccidia infection impossible as described by Herrick, Ott, and Holmes (1936).

In the first trial the chicks were fed a sterilized ration consisting of ground yellow corn 45, wheat bran 15, standard middlings 15, dried skimmilk 12, meat scrap 6, alfalfa leaf meal 3, chick size oyster shell 3, iodized stock salt 0.5, and cod liver oil 0.5. At four weeks of age the chicks were evenly divided into three lots and fed the following sterilized experimental rations for a period of two weeks. Lot 1 received the basal ration which consisted of ground yellow corn 45, wheat bran 15, standard wheat middlings 15, dried skimmilk 12, meat scrap 6, alfalfa leaf meal 3, iodized stock salt 0.5, and cod liver oil 0.5. Lot 2 received basal ration 97 percent and chick size oyster shell 3 percent; Lot 3 received basal ration 94 percent and chick size oyster shell 6 percent. After two weeks on the experimental rations the three lots of chicks were fed by pipette the same dosage of sporulated oocysts of a pure culture of *Eimeria tenella*. Approximately 200,000 sporulated oocysts were given to each chicken. Death loss and general conditions of the groups were noted. The results of the first trial are given in Table 1.

The results of the first trial seemed to

[1] Heated to 170°F. for 30 minutes—a temperature sufficient to kill oocysts of coccidia (Fish, 1931).

indicate that the addition of 6 percent chick size oyster shell to the basal ration resulted in a marked lowering of resistance to coccidiosis as evidenced by the extremely heavy mortality in lot 3. In this trial there was no significant difference in mortality rate obtained in the groups receiving 0 and 3 percent chick size oyster shell.

In the second trial the day-old chicks were placed in sterile brooders and were fed the same experimental rations as were used in the first trial. The three lots of chicks were infected when two weeks old. They were, however, given the same dosage of sporulated oocysts of the same pure culture of *Eimeria tenella* as used in the first trial. Death loss and general conditions of the groups were noted. The results of the second trial are given in Table 2. It is evident that when 3 and 6 percent chick size oyster shell was added the chicks were more seriously affected by coccidia as evidenced by the greater mortality in these groups.

In the third trial the day-old chicks were placed in sterile brooders and were given the same sterilized experimental rations as the preceding trials but were infected at four weeks of age with the same dosage of sporulated oocyts of the same pure culture of *Eimeria tenella* as used in the previous trials. The results (Table 3) show that the mortality from coccidiosis in the three lots was 46.8, 60.0, and 77.8 percent respectively when 0, 3, and 6 percent oyster shell was fed, showing that the addition of calcium carbonate in the form of chick size oyster shell increased the susceptibility of chickens to coccidiosis. In the last two trials the lowest mortality from coccidiosis was experienced when no chick size oyster shell (source of calcium carbonate) was added to the ration. In the first and third trials the heaviest mortality from coccidiosis occurred in the lots receiving 6 percent of chick size oyster shell. The results of the three trials summarized in Table 4 indicate that with the higher levels of calcium carbonate, as supplied by chick size oyster shell, more deaths occurred after infection with coccidiosis.

Chemical analyses of the three experimental rations for calcium and phosphorous content were made. The calcium, phosphorous, and calcium to phosphorous ratio for the three experimental rations is given in Table 5. It will be noted that when no addition of chick size oyster shell was made to the basal ration there was a calcium con-

TABLE 1.—*Results of first trial*

Ration		Number	Average* weight at 6 weeks	Survivors	Average weight of survivors at 7 weeks	Deaths from coccidiosis (percent)	Deaths from coccidiosis 5th day	6th day	7th day	Average weight at death
			grams		grams					grams
Lot 1 Basal	100	42	249.1	27	287.4	35.7	0	14	1	254.5
Lot 2 Basal Chick size oyster shell	97 3	39	225.0	27	266.0	30.8	0	10	2	245.1
Lot 3 Basal Chick size oyster shell	94 6	39	251.4	11	272.9	71.8	5	20	3	256.6

* Infected at six weeks of age.

TABLE 2. *Results of second trial*

Ration	Number	Average weight at start	Average* weight at 2 wks.	Survivors	Average weight of survivors at 3 weeks	Deaths from coccidiosis (percent)	Deaths from coccidiosis 3rd day	4th day	5th day	6th day	7th day	Average weight at death
		grams	grams		grams							grams
Lot 1 Basal 100	43	40.5	78.0	19	90.7	55.8	3	1	8	11	1	77.7
Lot 2 Basal 97 Chick size oyster shell 3	44	42.4	81.3	14	88.1	68.2	3	0	10	16	1	84.4
Lot 3 Basal 94 94 Chick size oyster shell 6	45	41.3	75.3	16	79.8	64.4	7	2	8	11	1	68.3

* Infected at two weeks of age.

tent of 0.8714 percent and a ratio of 1 part of calcium to 1.07 parts of phosphorus; when 3 percent of chick size oyster shell was fed there was a calcium content of 1.293 percent and a ratio of 1 part of calcium to 0.74 parts of phosphorus; when 6 percent of chick size oyster shell was fed there was a calcium content of 2.471 percent and a ratio of 1 part of calcium to 0.354 parts of phosphorus.

These trials are in agreement with the preliminary results reported by Herrick, Ott, Halpin, and Holmes (1935) and seem to indicate that excessive mineral additions are likely to be detrimental to growing chicks when sporulated coccidia oocysts are fed in measured amounts.

These trials were repeated with an attempt to maintain rations with the same calcium to phosphorus ratio. The calcium to phosphorus ratio was adjusted by adding sufficient disodium phosphate ($Na_2HPO_4 \cdot 12H_2O$) to maintain the same ratio in all three lots. The same basal ration was used as in the three previous trials. The general plan of the rations was: lot 1—

TABLE 3.—*Results of third trial*

Ration	Number	Average weight at start	Average* weight at 4 weeks	Survivors	Average weight at 5 weeks	Deaths from coccidiosis (percent)	Deaths from coccidiosis 5th day	6th day	7th day	Average weight at death
		grams	grams		grams					grams
Lot 1 Basal 100	47	40.1	149.4	25	166.2	46.8	1	19	2	155.7
Lot 2 Basal 97 Chick size oyster shell 3	40	40.3	165.4	16	169.6	60.0	0	21	3	164.7
Lot 3 Basal 94 Chick size oyster shell 6	45	41.4	155.8	10	168.8	77.8	1	31	3	149.0

* Infected at four weeks of age.

basal, no additions; lot 2 basal plus 3 percent chick size oyster shell and disodium phosphate; lot 3—basal plus 6 percent chick size oyster shell and disodium phosphate. To adjust the calcium to phosphorus ratios 863.5 and 3,620.4 grams of disodium phosphate were added to each 100 pounds of ration of lots 2 and 3 respectively. The trials were started with day-old chicks in sterile brooders fed the sterilized experimental rations. The chicks in lots 2 and 3 would not eat their rations readily and a majority of the chicks in these two lots died of starvation. The remaining chicks in lots 2 and 3 made little growth. The experiment was completed, but because only a few very badly stunted chicks remained in lots 2 and 3 at the time of infection, no significant results were obtained as to the resistance to coccidiosis at different levels of calcium carbonate when the calcium to phosphorus ratio was held constant.

One group of day-old chicks was placed in a battery brooder. They were given the Wisconsin 2A starting ration in one feed trough and in the other feed trough the same ration as lot 3: 3,620.4 grams of disodium phosphate in 100 pounds of ration. Wisconsin 2A consists of ground yellow corn 45, wheat bran 15, standard wheat middlings 15, dried skimmilk 12, meat scrap 6, alfalfa leaf meal 3, chick size oyster shell 3, iodized stock salt 0.5, and cod liver oil 0.5. The feed troughs were interchanged frequently in order to overcome any influence of difference in light intensity or habit on food consumption. In the twenty-two-day period the chicks had consumed only 452 grams of the ration containing the additional disodium phosphate and had consumed in the same time 7,432 grams of the Wisconsin 2A starting ration that contained no addition of disodium phosphate. Rations containing the amounts of disodium phosphate used in these trials are unpalatable and if studies are to be made with different levels of calcium carbonate holding the calcium to phosphorus ratio constant some other source of phosphorus must be used.

TABLE 4.—*Summary of three trials*

Ration		Number of chicks infected	Deaths from coccidiosis	Percent mortality from coccidiosis
Basal	100	132	61	46.2
Basal Chick size oyster shell	97 3	123	66	53.6
Basal Chick size oyster shell	94 6	129	92	71.3

TABLE 5.—*Calcium and phosphorus contents of rations*

Ration		Calcium percent	Phosphorus percent	Calcium to phosphorus ratio
Basal	100	0.8714	0.9343	1.0:1.07
Basal Chick size oyster shell	97 3	1.293	0.9636	1.0:0.74
Basal Chick size oyster shell	94 6	2.471	0.8862	1.0:0.354

SUMMARY

1. In two trials more deaths occurred after infection with coccidiosis when 6 percent of chick size oyster shell was added to a basal diet containing 0.8714 and 0.9343 percent calcium and phosphorus respectively.

2. The results of the three trials indicate that with the higher levels of calcium carbonate more deaths occurred after infection with coccidiosis.

3. Attempts to determine the effects of different levels of calcium carbonate on

mortality from coccidiosis holding the calcium to phosphorous ratio constant by means of disodium phosphate were not successful due probably to unpalatability of the rations containing this phosphorus supplement.

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News and Notes

At the recent annual meeting of the Poultry Science Association at Madison, Wisconsin, R. E. Jones of Storrs, Connecticut, was elected President for the year 1937-38. Berley Winton of Washington, D.C., was elected 1st Vice-President and L. W. Taylor of Berkeley, California, was elected 2nd Vice-President. W. A. Maw of Macdonald College, Quebec, Canada, was reëlected Secretary-Treasurer. The directors elected for the period 1937-39 were R. B. Thompson of Stillwater, Oklahoma, and M. O. North of Laramie, Wyoming. G. W. Sprague of Washington, D.C., was elected an associate editor of POULTRY SCIENCE.

The Executive Committee of the Poultry Science Association decided to hold the next annual meeting of the Association at Washington State College, Pullman, Washington, after a guiding vote indicating the preference of the members present at the annual meeting, had been taken.

The Seventh World's Poultry Congress will be held in Cleveland, Ohio, where excellent facilities are available for housing the Congress. It is expected that the Congress will be held sometime during the period covering the last week in July and the first week in August.

Dr. Victor Heiman, Assistant Professor of Poultry Husbandry, Washington State College, has resigned to become associated with Kasco Mills, Inc., Waverly, New York, on August 1 as director of research.

Dr. Lawrence L. Lachat has resigned from the Minnesota State Department of Agriculture, effective August 15, to head the new Feed Testing and Control Laboratory of the Great Atlantic & Pacific Tea Company. Dr. Lachat will have his head-quarters at Minneapolis, Minnesota.

Color-Producing Genes in White Silkie and White Rose Comb Bantam

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(Received for publication April 13, 1937)

INVESTIGATIONS at the National Agricultural Research Center, Beltsville, Maryland, have shown that considerable diversity in genotypes exists among white varieties of fowls, probably due to intercrossing of white phenotypes. The results obtained in a study of five white varieties (Quinn, 1936) indicated that the history of the development of some of these varieties may not prove a reliable criterion for the heredity of any particular strain or family, and that only by experimental testing can the genetic constitution be definitely determined.

Among the white varieties studied were the White Silkie and White Rose Comb Bantam, concerning the origin of which little is known. However, Bateson and Punnett (1908) found strains of White Silkies and White Rose Comb Bantams which were recessive whites and lacked one of the complementary color-producing genes, AAbb, as proposed by Punnett (1923). They were later designated CCoo, crosses of these two white breeds with ccOO white breeds producing all colored chicks, CcOo.

Early in 1932, however, reciprocal crosses of White Silkies and White Wyandottes at the National Agricultural Research Center produced white chicks instead of colored, as would be expected from a CCoo × ccOO cross. The recessiveness of both the White Silkies and White Wyandottes had been adequately demonstrated by previous crosses with colored varieties, as described in a previous paper (Quinn, 1936). Punnett (1933),[1] when informed of these results, stated that he had recently found White Silkies which were, like the White Wyandotte and White Pymouth Rock, recessive for the complementary color-producing genes CC.

In the meantime reciprocal crosses of White Rose Comb Bantams with White Silkies, and reciprocal crosses of F_1 (White Rose Comb × White Silkies) with F_1 (White Silkie × White Wyandotte), had demonstrated that the White Rose Comb Bantams tested at Beltsville lacked the same complementary color-producing genes as the White Silkie and White Wyandotte (Quinn, 1936). In order to determine whether or not the White Silkies and White Rose Comb Bantams tested at Beltsville were typical of the breeds in the United States, it was decided to obtain additional White Silkie and White Rose Comb Bantam stocks to study the genetic constitution of other strains of these breeds in respect to the color producing genes C and O. Four unrelated strains of White Silkies and one strain of White Rose Comb Bantams were used in this investigation.

THE WHITE SILKIE

Eight reciprocal matings of the four unrelated White Silkie strains were made with cc White Wyandotte males and females.

[1] Punnett, R. C., 1933. Personal communication.

From these matings, 472 chicks were obtained, all of which were white instead of colored. These results show that the reciprocal White Silkie-White Wyandotte matings were cc matings, unless it is assumed that the White Silkies were dominant whites, an untenable assumption, as will be shown in other crosses.

In order to demonstrate the recessiveness of the White Silkies, reciprocal matings were made between the same four strains of White Silkies and the following: Rhode Island Reds, Jungle Fowls, Black Sumatra Bantams, and F_1 (Rhode Island Red × Barred Plymouth Rock) crossbreds. From these crosses 684 colored chicks were obtained, demonstrating that all four strains of White Silkies were recessive. This fact, in addition to the results of the White Wyandotte-White Silkie matings previously mentioned, indicates that the White Silkies lacked the same color producing genes as the White Wyandotte, CC. These White Silkies, then, may be designated as ccoo, or ccOO. As stated previously, the strains of White Silkies reported by Punnett (1923) were CCoo whites differing from the White Wyandottes, ccOO whites.

In order to determine whether or not the White Silkies carried the CCoo genes, F_1 matings were made, using the progeny of the matings of the White Silkies with the colored varieties previously described. The matings of White Silkies × colored varieties should give CcOo or CcOO progeny, depending on the genetic constitution of the White Silkie in respect to the O gene. If the White Silkie × colored crosses produced CcOo offspring in the F_1 generation, a ratio of 9 colored to 7 white would be obtained in the F_2. On the other hand, if these crosses produced CcOO offspring there would be a single gene difference, and the F_2 ratio would be 3 colored to 1 white, as shown in Table 1.

Davenport (1906), Cunningham (1912),

TABLE 1.—*Down color of chicks from F_1 matings of White Silkies × colored fowls*

F_1 matings	Number of chicks	
	Colored	White
F_1 ♂ (W. Silkie ♂ No. 1×R. I. Red ♀)×F_1 ♀♀ (W. Silkie ♂ No. 1×R. I. Red ♀♀)	210	67
F_1 ♂ (R. I. Red ♂×W. Silkie ♀ No. 1)×F_1 ♀♀ (R. I. Red ♂×W. Silkie ♀♀ No. 1)	373	134
F_1 ♂ (R. I. Red ♂×W. Silkie ♀ No. 2)×F_1 ♀♀ (R. I. Red ♂×W. Silkie ♀♀ Nos. 2, 3, 4)	896	314
F_1 ♂ (W. Silkie ♂ No. 3×Jungle Fowl ♀)×F_1 ♀♀ (W. Silkie ♂ No. 3×Jungle Fowl ♀♀)	30	8
F_1 ♂ (Jungle Fowl ♂×W. Silkie ♀ No. 3)×F_1 ♀♀ (Jungle Fowl ♂×W. Silkie ♀♀ No. 3)	45	12
F_1 ♂ (Black Sumatra Bantam ♂×W. Silkie ♀ No. 4)×F_1 ♀♀ (Bl. Sum. Bantam ♂×W. Silkie ♀♀ No. 4)	58	21
F_1 ♂ (F_1 ♂ (R. I. Red ♂×B. P. R. ♀)×W. Silkie ♀ No. 1)×F_1 ♀♀ (F_1 ♂ (R. I. Red ♀×B. P. R. ♀)×White Silkie ♀♀ Nos. 1, 2, 3, 4)	136	44
Observed	1,748	600
Expected from CcOo mating (9:7 ratio)	1,320.75	1,027.25
Expected from CcOO mating (3:1 ratio)	1,761	587

Bonhote (1914), and others have made crosses of White Silkies × colored fowls and found the white of the Silkie recessive to color, a single gene being responsible for the difference between these White Silkies and the colored fowls. This gene may have been the recessive o gene of the CCoo White Silkies or the c gene of ccOO White Silkies. In no case, however, had any preliminary test of the White Silkies been made with cc whites.

Further proof that the White Silkies were ccOO whites and not ccoo whites is given in the back cross matings in Table 2. If the White Silkies were, as previously represented, oo whites, the back cross mating of F_1 (White Silkie × colored fowl) × White Silkie would be a CcOo × ccoo mating, from which a 3:1 ratio of white to colored chicks would be expected, whereas a 1:1 ratio of colored to white chicks was observed, indicating a CcOO × ccOO mating.

THE WHITE ROSE COMB BANTAM

Little seems to be known about the origin of the White Rose Comb Bantams. Punnett (1923) in a discussion of the genetics of the recessive whites states: "Of two factors necessary for the production of a fully colored bird, the Silkie contains one and the recessive white the other. It is probable that of these two factors the White Rose Comb lacks the same one that the Silkie lacks. Though this was not proved directly by crossing the Rose Comb with the recessive white, it was shown indirectly by mating a white F_1 (Silkie × Rose Comb) hen with a recessive white cock. All of the 28 offspring were colored, from which it may fairly be inferred that the cross Rose Comb × recessive white would give none but colored birds. This evidence supports the contention, already set out above, that the Silkie and Rose Comb are both differentiated from the fully-colored bird through

TABLE 2.—*Down color of chicks from reciprocal back cross matings of White Silkies × F_1 colored fowls*

Back cross matings	Number of chicks	
	White	Colored
White Silkie ♂ No. 1×F_1 ♀♀ (R. I. Red ♂×W. Silkie ♀♀ No. 1)	23	25
White Silkie ♂ No. 2×F_1 ♀♀ (R. I. Red ♂×W. Silkie ♀♀ No. 2)	73	68
White Silkie ♂ No. 3×F_1 ♀♀ (Jungle Fowl ♂×W. Silkie ♀♀ No. 3)	30	27
White Silkie ♂ No. 4×F_1 ♀♀ (R. I. Red ♂ ×W. Silkie No. 4)	58	61
F_1 ♂ (R. I. Red ♂×W. Silkie ♀ No. 1)×White Silkie ♀♀ No. 1	87	73
F_1 ♂ (R. I. Red ♂×W. Silkie ♀ No. 2)×White Silkie ♀♀ Nos. 2, 3, 4	296	304
F_1 ♂ (Jungle Fowl ♂×W. Silkie ♀ No. 3)×White Silkie ♀♀ No. 3	49	46
F_1 ♂ (Bl. Sum. Bantam ♂×W. Silkie ♀ No. 4)×White Silkie ♀♀ No. 4	47	51
F_1 ♂ (R. I. Red ♂×B. P. Rock ♀)×W. Silkie ♀ No. 1)×White Silkie ♀♀ Nos. 1, 2, 3, 4	54	60
Observed	717	715
Expected ccoo×CcOo mating (3:1 ratio)	1,074	358
Expected CcOO×ccOO mating (1:1 ratio)	716	716

TABLE 3.—*Down color of chicks from F_1 matings of White Rose Comb Bantams × colored fowls*

F_1 matings	Number of chicks	
	Colored	White
F_1 ♂ (White Rose Comb ♂×Jungle Fowl ♀)×F_1 ♀♀ (White Rose Comb ♂×Jungle Fowl ♀♀)	43	18
F_1 ♂ (Jungle Fowl ♂×White Rose Comb ♀)×F_1 ♀♀ (Jungle Fowl ♂×White Rose Comb ♀♀)	29	12
F_1 ♂ (Bl. Sumatra Bantam ♂×W. Rose Comb ♀)×F_1 ♀♀ (Bl. Sumatra Bantam ♂×W. Rose Comb ♀♀)	19	5
Observed	91	35
Expected from CcOo mating (9:7 ratio)	70.9	55.1
Expected from CcOO mating (3:1 ratio)	94.5	31.5

lack of the same factor." Accordingly, the White Rose Comb, like the White Silkie, was assumed to be CCoo.

However, Quinn (1936) reported reciprocal crossings of White Rose Comb Bantams × White Silkies (ccOO), and F_1 matings involving the White Rose Comb Bantam and White Wyandotte, in which it was shown that the White Rose Comb Bantams lacked the same complementary color producing genes as the White Silkie and the White Wyandotte. They were, therefore, either ccoo or ccOO whites, and not, as the strains previously reported by Punnett, CCoo whites.

In order to determine whether or not the cc White Rose Comb Bantams carried the recessive oo genes, P_1, F_1, and back-cross matings were made with colored breeds. The P_1 matings of the White Rose Comb Bantams × colored breeds would give either CcOo or CcOO progeny depending on the genetic constitution of the White Rose Comb in respect to the O gene.

If the White Rose Comb × colored crosses produced CcOo progeny in the F_1 generation, a ratio of 9 colored to 7 white would be expected in the F_2. On the other hand, if the difference between the White Rose Comb, ccOO, and the colored breeds,

TABLE 4.—*Down color of chicks from back cross matings of White Rose Comb Bantams × F_1 colored fowls*

Back cross matings	Number of chicks	
	White	Colored
White Rose Comb Bantam ♂×F ♀♀ (W. Rose Comb ♂×Jungle Fowl ♀♀)	19	16
White Rose Comb Bantam ♂×F ♀♀ (Jungle Fowl ♂×W. Rose Comb ♀♀)	19	20
White Rose Comb Bantam ♂×F ♀♀ (Bl. Sumatra Bantam ♂×W. Rose Comb ♀♀)	27	31
Observed	65	67
Expected from a ccoo×CcOo mating 3:1 ratio	99	33
Expected from a ccOO×CcOO mating 1:1 ratio	66	66

CCOO, is a single gene difference, the F_2 ratio expected would be 3 colored to 1 white. The results in Table 3 show that the number of colored to white chicks closely approximated the 3:1 ratio. Therefore, the White Rose Comb Bantams used must have been of the genetic constitution ccOO.

The back-cross matings confirm the results of the F_1 matings since White Rose Comb males, ccOO, when mated to F_1 females, CcOO, gave a 1:1 ratio of colored to white chicks. Had the White Rose Combs been ccoo whites the back-cross matings would have been ccoo × CcOo matings from which a 3:1 ratio of white to colored chicks would have been obtained.

Previous crosses of White Rose Comb Bantams with Black Rose Comb Bantams have been made by Bateson and Punnett (1908) and Jull and Quinn (1929). The former found the white of the Rose Comb White Bantams recessive to the color of the blacks and that a single gene was responsible for the presence of color, since 70 black and 24 white progeny were obtained in the F_2 generation. Jull and Quinn also obtained a 3:1 ratio of colored to white in the F_2 progeny. Unfortunately, no preliminary testing of the White Rose Comb Bantams with cc whites had been made in either case prior to making the crosses with the blacks. It is possible in both the cases cited above, that the White Rose Combs used may have been CCoo whites but such was not the case in the White Rose Combs studied in the present investigation since crosses with cc whites (White Silkies, and White Silkie × White Wyandotte crosses), had previously established the fact that the White Rose Combs lacked the CC genes. The hypothesis that the Beltsville White Rose Combs might be ccoo whites has been disproven by the results given in Tables 3 and 4.

SUMMARY

Four unrelated strains of White Silkies and one strain of White Rose Comb Bantams were found to carry the genes ccOO, instead of the genes CCoo, as found in strains studied by previous investigators.

The results of this investigation in no way invalidate the previous findings in regard to the White Silkie and White Rose Comb Bantam, but they do indicate the diversity existent among white breeds in respect to plumage color, and further demonstrate the necessity of preliminary experimental testing to determine definitely the genetic constitution of white breeds and varieties which are to be used in studies of plumage color or shank color.

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Abstracts of Papers

Presented at the

29th Annual Meeting—August 10 to 13, 1937

University of Wisconsin

4. THE RECOVERY OF LAYING PULLETS FROM CECAL COCCIDIOSIS AS AFFECTED BY FEEDING VARYING AMOUNTS OF COD LIVER OIL

R. R. Murphy, J. E. Hunter and H. C. Knandel, *Pennsylvania State College*

Incident to a study of the vitamin D requirements of laying pullets opportunity was afforded for preliminary observations on the effects of feeding gradient amounts of cod liver oil on the subsequent mortality, body weight, and egg production of eight groups of pullets following a severe infestation of the cecal type of coccidiosis. Amounts of oil fed ranged from 1/16 of 1 percent to 1 percent. The pullets became infested in a natural manner when 26 weeks old. At the time the disease appeared the pullets receiving ¼ of 1 percent or more of cod liver oil were in excellent condition and in satisfactory egg production.

Following the attack of coccidiosis, body weight and egg production decreased. A more severe drop in egg production occurred in the groups fed the lower levels of oil. Recovery of normal body weight and satisfactory egg production was more rapid in the groups on the higher oil diets. As the amount of cod liver oil in the ration was increased, the rate of mortality following the infestation of coccidia decreased. There appeared to be a direct relationship between the amounts of cod liver oil concentrate fed and the performance of pullets following an attack of coccidiosis.

Body weight, egg production, and mortality data indicate that the feeding of adequate levels of cod liver oil is of considerable value in overcoming some of the detrimental effects brought about by a severe infestation of cecal coccidia. The substance or substances contained in cod liver oil responsible for the rapid recovery of laying pullets from coccidiosis was not determined. To determine this and other points concerning the problem further work will be necessary.

5. THE INFLUENCE OF SUMMER TEMPERATURES ON THE GROWTH OF CHICKENS

H. L. Kempster, *University of Missouri*

Growth studies are of economic importance to the poultry raiser. The Missouri Agricultural Experiment Station has established growth standards for White Leghorn, Rhode Island Red, and White Rock pullets. Having established normal growth curves for these three breeds and having determined how much the normal chicken increases in weight these figures can be used to note the fluctuations of various groups of chickens with respect to growth. The early hatched chicks grew much faster when young than did those chicks hatched in April or later. At the age of 20 weeks the early hatched pullets were from 14 to 20 percent heavier depending upon the breed.

The extreme difference in weight between early and late hatched pullets which occurred at the age of 20 weeks gradually disappeared until at the age of 28-32 weeks the pullets hatched in early February were no larger than those hatched in April. This behavior illustrates a fundamental principle of growth which is that when retarded growth occurs it is compensated for by accelerated growth later when conditions are favorable. In these studies the conclusion has been reached that the high maximum temperatures that prevail during the summer months is largely responsible for the retarded growth of the late hatched pullets. The retarding effect of high temperatures is more pronounced with the larger chicks.

6. THE USE OF COTTONSEED MEAL IN THE CHICK STARTING RATION

R. C. Ringrose and C. L. Morgan, *South Carolina Experiment Station*

Two series of duplicate experiments were conducted using prime quality cottonseed meal (41

percent) as a protein supplement. The results indicate that cottonseed meal may be used satisfactorily in a starting ration for chicks when properly supplemented to supply the required minerals and vitamins.

In the first series of experiments cottonseed meal was used to replace up to three-quarters of the meat scrap protein. Mineral additions were made where necessary and 7.5 percent of dried whey and 5 percent of alfalfa meal were used as sources of vitamin G. Growth on the cottonseed meal rations was equal to that on the control ration which was composed of yellow corn meal, wheat middlings, meat scrap, dried whey, and alfalfa meal.

In the second series of experiments a combination of equal parts of protein from cottonseed meal and meat scrap was supplemented with alfalfa meal and dried whey in order to determine the quantity of these supplements needed to supply vitamin G. The sample of meat scrap used was relatively potent in this vitamin since a ration containing 5 percent of alfalfa meal with this protein combination gave growth equal to rations in which 5 percent of alfalfa meal and 2 percent or more of whey were used as sources of vitamin G.

7. THE RESPONSE OF GROWING CHICKS TO CERTAIN SPACE FACTORS

H. ERNEST BECHTEL, CARL H. SCHROEDER, AND W. O. WILSON, *Larro Research Farm*

These investigations concern the influence of certain space factors on the response of growing chicks fed a practical ration and brooded in batteries or under electric hovers. The criteria of response, used in these studies, include rate and cause of mortality, growth rate, feed consumption, intensity of shank pigmentation, and completeness of feathering.

One phase of the investigation in batteries was designed to study the development of chicks when pen space per bird and pen space per unit live weight were kept relatively constant. Two series of pens of uniform size were used in this test. The initial population in each of one series of pens varied from three to 50 chicks and space per bird varied from 0.1 to 1.1 cubic feet in the respective pens. The initial population in each of the second series of pens also ranged from three to 50 chicks but, after the fourth week, the number of birds per pen was gradually reduced in order to provide a range of 0.3 to 7.5 cubic feet of space per kilogram live weight in the respective pens.

In progress at the time of preparing this abstract are tests designed to study the development of birds in batteries as affected by size of group population when pen space per bird has been equalized in all groups. Other tests, in progress, deal with the effects of varying amounts of feeding space on growth and development.

8. THE EFFECT OF REARING ENVIRONMENT ON SEXUAL DEVELOPMENT

E. W. CALLENBACH AND J. E. NICHOLAS, *Pennsylvania State College*

Controlled experiments with 2,000 Single Comb White Leghorn and Barred Plymouth Rock pullets were conducted to determine the influence on sexual development of the rearing environment variables, brooder house temperature, brooder house humidity, source of heat under or about the brooder, and the ration consumed.

Room temperature, which was taken 29 inches from the edge of the brooder canopy and two inches above the litter varied from —2 degrees to 92 degrees Fahrenheit during 15-week brooding periods. Room temperature had no measurable effect upon sexual development.

The relative humidity, determined by a sling psychrometer, varied from 5 to 90 percent. Relative humidity had no measurable influence upon sexual development.

The brooders used were heated by means of coal, electricity (using exposed, black heat resistance coils), oil, gas, and hot water. Pullets brooded with electricity where the heat was applied by means of exposed, black heat resistance coils required 17 to 25 days for Single Comb White Leghorns and 25 to 33 more days for Barred Plymouth Rocks to attain sexual maturity.

All groups of pullets were fed the regular Penn State chick starter mash for the duration of the experiments. The grain mixture was likewise fed ad libitum after the fourth week for series 1 and 2, after the eighth day for series 3, and after the third day for series 4. The protein level of the ration consumed did not influence age at sexual maturity. Heavy grain consumption by immature pullets did not retard sexual development.

9. COMPARATIVE GROWTH AND FEED CONSUMPTION OF COCKERELS AND CAPONS

G. E. ANNIN AND J. G. HALPIN,[1] *University of Wisconsin*

The data in this report are the result of a two years' study. Three hundred sixty-four birds were used including pure bred Barred Rocks, Rhode Island Reds, New Hampshires, and cross bred

Rock-Reds, Red-Rocks, and New Hampshire-Rocks.

With the strains used in this study there was not a significant difference in the rate of growth or in feed consumption between the pure bred capons and cockerels or between the crossbred capons and cockerels or between purebreds and crossbreds.

The average weight at 28 weeks of age for all capons was 3,198 grams and for all cockerels 3,187 grams.

From a producer's standpoint the capons had an advantage over the cockerels only because of the premium that certain markets would pay.

10. THE EFFECT OF FATTENING AT DIFFERENT AGES ON THE COMPOSITION OF COCKERELS

H. M. HARSHAW, *U. S. Department of Agriculture*

Ten crossbred cockerels were selected at random from a larger group, reared under normal conditions on the range at each of the ages of 8, 12, 16 and 20 weeks and subjected to physical and chemical analyses. Ten additional cockerels were selected at each of these ages, fattened for two weeks and subjected to the same analyses.

There were differences between the fattened birds and the corresponding unfattened ones, in the ratios of the various edible portions to live weight, and these differences were apparently not due to the differences in the age of the birds. Within each class of birds the percentages of leg muscle and of total edible portion increased with age, while those of the breast muscle and remaining edible portion remained practically the same.

The percentage of protein, ash, fat, and water in the tissues was affected by the degree of fattening rather than by the age of the birds. With a higher percentage of fat, there was a correspondingly lower percentage of the other constituents. The estimated amount of fat put on during fattening increased with age, but the estimated increase in the other constituents remained approximately the same at all ages.

11. PROGENY TESTS AS AN EXTENSION PROJECT

L. E. WEAVER, *Cornell University*

A number of progressive New York State breeders were convinced that they were not making full and best use of their trap-nested birds. Inquiries were coming into the Poultry Department for more and detailed information about the use of the Progeny Test, what records should be kept, what forms used, and so forth. An extension project was set up by which a group of volunteer coöperators agreed to carry out the plan prepared by department specialists, and on forms supplied by the department.

The forms that were prepared followed very closely the plan developed by R. T. Argood at the Norfolk County Agricultural School in Massachusetts. The project was carried through as agreed by all but two coöperators, with from two pens to 10 pens per breeder. The project has received the enthusiastic endorsement of the coöperators as indicated by the fact that all are repeating in 1937, and several others have been added. Care in the admission of additional coöperators and limitation of numbers seem desirable.

12. MONTHLY WEIGHT CHANGES OF WHITE LEGHORN PULLETS IN RELATION TO CONCURRENT EGG WEIGHT AND RATIONS

E. W. HENDERSON,
Iowa Agricultural Experiment Station

The objectives of this study were to determine whether or not correlations between the rate of increase of pullet weight and the rate of increase of egg weight, during the "growing" period (October to January) are affected by variations in protein content of the rations.

The data include monthly body weights of 192 Single Comb White Leghorn pullets and the daily egg weight of the same pullets during the same periods of time.

Neither the rate of increase of pullet weight or egg weight was affected significantly by the variations in protein content of the rations. The rate of increase of egg weight of individual pullets during the growing period was not influenced by the rate of increase of body weight during the same period. The correlations between these two variables within the between pens were not significant.

The number of months required to attain maximum egg size decreased slightly with increased percentages of protein but the trend was not consistent above the protein content of 13.4 percent. Maximum egg size was attained in an average of 5.3 months when the ration contained 12.3 percent protein and in 4.4 months in two pens when the ration contained 13.4 percent and 14.8 percent protein respectively.

It is suggested that egg weight may be dependent

on size or capacity of body or oviduct instead of body weight. If this is the case the most rapid attainment of maximum egg size by pullets in the autumn might be expected from rations which stimulate rapid growth of body framework, therefore "fattening" rations may delay the attainment of maximum egg size.

13. THE USE OF INBRED FOWLS FOR TOP-CROSSING

N. F. WATERS, *Iowa State College*

The principle of top-crossing inbred sires with other birds of the same breed has in effect been demonstrated in plants when inbred strains of corn are crossed with commercial strains. Ample evidence is available in the field of corn breeding to show the value of such top-crossing with good inbred strains.

The evidence presented in this report would indicate that top-crossing with good inbred strains of birds increases the fertility and hatchability of the top-cross progeny over either the inbred and non-inbred parents.

This summary reports the results obtained from 38 Leghorn, 93 Inbred Leghorn and 54 Top-Cross Leghorn birds made during a period of four years. Each year a Non-Inbred Leghorn mating was used as a control. Birds highly related to the Non-Inbred Leghorns were placed in matings with Inbred Leghorn sires who were also mated to inbred sisters or half sisters. The inbreeding coefficients for the inbreds in the different matings ranged from 40 to 82 percent.

The top-crosses performed better in regard to fertility, hatchability and mortality to eight weeks although the differences between groups was not in all cases significant. It may be assumed in as much as the females used in the top-crosses were highly related to the non inbreds that the beneficial effects found in the top-crosses were due to the use of inbred sires.

14. POSSIBILITIES IN SELECTION

H. D. GOODALE,
Mount Hope Farm, Williamstown, Massachusetts

Actual results of selection in certain cases will be presented and the amount of change which may be expected on theoretical grounds will be considered. It will be shown that grounds exist for believing that the possibilities in selection are much greater than is generally realized.

15. EFFECTIVE QUANTITIES OF SEMEN IN ARTIFICIAL INSEMINATION

WILLIAM H. BURROWS,
U. S. Department of Agriculture

A study of over 5,000 eggs from artificially-inseminated hens was made to determine (1) the minimum effective quantity of semen to produce maximum fertility in hens; (2) the optimal quantity necessary to produce the largest number of chicks for the amount of semen utilized; and (3) the most economical quantity when both the supply of semen and the labor involved are factors under consideration.

Ten or more hens and 300 or more eggs were used in each of the various determinations. In all experiments which required amounts under 0.05 c.c. the injections were made with a micro-syringe. Rhode Island Red, crossbred (Rhode Island Red × Barred Plymouth Rock) hens and Rhode Island Red pullets were utilized in this study.

No difference in fertility appeared between hens of the two breeds, but year-old hens yielded slightly better fertility than pullets with the same treatment. Quantities were studied which ranged from 0.02 c.c. to 0.1 c.c. and the frequency of inseminations was determined to be optimal for most purposes as one insemination a week. With this frequency of insemination, 0.1 c.c. of semen yielded about 90 percent fertility, 0.05 c.c. about 85 percent fertility, and 0.02 c.c. about 50 percent fertility. These compare with a general value of about 85 percent for natural flock matings of similar birds during the same season under usual conditions of management.

16. PERMEABILITY OF EGGSHELL TO VARIOUS GASES

ALEXIS L. ROMANOFF, *Cornell University*

The permeability of gases through the fowl's eggshell is one of theoretical interest and of considerable economic importance. It may reveal causes of embryonic mortality or lead to new efficient methods of preservation of eggs.

The analysis of the present data, obtained by means of perfected apparatus for the accurate measurement of continuous flow of a gas through the shell, indicates that the permeability of the shell varies as follows: (1) it is lower in the presence of inner membrane; (2) it is more permeable at the blunt than at the sharp end; (3) it has direct relationship with the amount of retained water in the pores; (4) it increases at the blunt and decreases at the sharp end with successive

eggs in the cycle; (5) it is constant among the eggs of any one hen; (6) it has no relationship to either breaking strength or thickness; (7) it increases with embryonic development more rapidly at the blunt than at the sharp end; (8) the shell is less permeable to oxygen and more permeable to nitrogen, carbon dioxide and especially to hydrogen than to air; and (9) the permeability increases with age at high humidity with high CO_2 and decreases at low humidity *with high content of* CO_2.

18. THE USE OF EXTENSION AGENCIES IN A POULTRY PROGRAM

J. B. HAYES, *University of Wisconsin*

Following an intensive poultry program consisting of culling demonstrations, housing bees, brooding demonstrations, result demonstrations, radio talks, chick rearing contests, news articles, disease clinics, and circular letters in a typical dairy county of Wisconsin, a farm to farm survey of a school district in each of four townships was conducted. Reports indicating exposure to extension methods and adopted practices were obtained.

Reduction of problems to single solutions, creating a personal need for such solutions were basic needs.

News stories, circular letters, bulletins, indirect, and radio were listed among the exposures that brought greatest changes in practices.

19. THE ECONOMICS OF SURPLUS POULTRY PRODUCTS REMOVAL UNDER THE A.A.A.

J. H. RADABAUGH,
Agricultural Adjustment Administration

The removal of surplus agricultural commodities (except dairy and beef cattle products) is authorized by Section 32 of the Agricultural Adjustment Act which appropriates 30 percent of the gross customs receipts for this and other purposes. Poultry products are purchased under clause 2 of that section which provides for encouragement of domestic consumption by removal from normal channels of trade and commerce.

The initiation of a program requires painstaking economic analysis of all factors involved and the existence of a definite surplus must be demonstrated. Programs are subject to review by interested bureaus and divisions.

After approval, purchases are made by the Commodities Purchase Section with advice from the Poultry Section. Factors to be considered in operation are: Areas of purchase; grades and qualities; prices to be paid; time of purchase; volume to be purchased; method of purchase; and, efficient distribution of product purchased. Season of the year is an important consideration in determining the practical aspects of purchases.

The immediate objective is always some effect on price. This includes attempts to ease producers' distress, to reduce retail price spreads or to adjust producer or wholesale price differentials between markets or grades. Longer-time objectives are far more important and are given more consideration. These are ordinarily concerned with supply rather than price considerations. For example, the recent egg purchase program was designed to encourage a more nearly normal production for late 1937 and 1938.

20. THE STATUS OF COÖPERATIVE POULTRY AND EGG MARKETING ASSOCIATIONS

ROY W. LENNARTSON AND JOHN J. SCANLAN,
Farm Credit Administration

The most important development in the coöperative marketing of poultry and eggs during the past 10 years has been that of the country poultry and egg auction associations in areas adjacent to the large consuming centers of the East. The chief factors responsible for the continuing success, growth, and increase in number of the auction type of association marketing eggs and poultry are: (1) adherence to strict grades and standards on produce sold; (2) members are paid according to the quality of produce sold; (3) the method of selling is simple and has made possible low handling costs; (4) producers and many buyers like the visual method of sale; (5) the establishment of these auctions in areas of surplus and high quality production adjacent to large consuming centers.

The methods of operating were originally much the same for all of these auctions. However, differences in production and marketing conditions, increased volumes, and experience have already made some changes in policies and methods of operation necessary in some instances. More attention needs to be given to additional membership relation work, financial policies, additional sales outlets, and consumer education. Some thought probably should be given the need for coördinating the efforts of the auctions in carrying on some of the above activities through joint effort for their mutual benefit.

21. A REVIEW OF RECENT LITERATURE ON THE STORAGE OF EGGS AND POULTRY

George F. Stewart,
Omaha Cold Storage Company

I. Storage of Eggs

The seven ascertained factors determining successful storage of eggs are:

1. Original fresh egg quality.
2. Sterility of egg contents.
3. Prevention of micro-organism growth on shell.
4. pH of egg contents.
5. Prevention of absorption of flavors
6. Prevention of evaporation.
7. Temperature.

Initial quality remains the dominant factor in storage of eggs. Humidity requirements for mold growth have been established. Flavor changes have been traced to chemical changes as well as absorption of foreign flavors.

II. Storage of Poultry

Desiccation during storage is one of the major faults of the storage poultry. The relation of "store burn, pock marking and freezer burn" to dehydration in storage is well established. Control has been achieved by moisture-vapor proof wrappings, —20°F. or lower storage temperatures, glazing, and so forth, and humidification of storage rooms.

Quick freezing as applied to poultry has as yet to prove its exact worth.

Drawn poultry is being widely introduced and presents many unanswered problems for research.

22. THE ANTIRACHITIC VALUE OF SUNLIGHT LAMP (TYPE S-L) RADIATION FOR LAYING HENS

F. E. Mussehl and C. W. Ackerson,
University of Nebraska

The egg production, hatchability, and condition quality of two groups of 125 Leghorn pullets of comparable breeding and environmental background during the growth period was observed. Lot "CLO 36" received 2 percent of standard quality cod liver oil in the mash, and lot "S-l '36" was provided chance exposure for two hours each morning to the energy produced by an S-l type lamp placed 60 inches above the floor.

A preliminary conclusion which may be drawn from this experiment is that Leghorn hens can be maintained in good condition, and will respond with a very satisfactory production when the antirachitic factor is provided during the winter months in the amount and of the quality provided with this equipment. Mortality, culling, and hatchability were quite comparable in both groups. No conclusion as to the physiological effect of the continued use of cod liver oil at rather high levels can fairly be drawn.

23. CONSUMPTION OF POULTRY IN NEW YORK CITY

A. Sturges and Gordon W. Sprague,
U. S. Department of Agriculture

Many of the marketing problems of the live poultry industry in New York City are due to declining volume of live poultry receipts over the past few years. They may be intensified by a further reduction in volume in the future, or partly remedied by its increase. Since the volume of receipts is largely governed by consumer demand, the factors affecting consumption are worth study in forming an estimate of the future.

Data were collected from over 8,000 families showing purchases weekly during March and April in 1935. Records were gathered in proportion to the number of families in 70 districts comprising all of New York City proper except the Borough of Richmond. The data showed the amount of poultry purchased, the class, and the price for each family by nationality, size of family, and average weekly income.

This survey showed that four dominant forces influenced the decision on the part of consumers to purchase poultry and the amount to be purchased. The decision to purchase poultry was afferted by nationality and income. The amount to be purchased was affected by size of family and price.

24. A COMPARISON OF DRY MILK, MEAT AND BONE MEAL AND COMBINATIONS OF BOTH AS PROTEIN SUPPLEMENTS FOR EGG PRODUCTION

E. W. Henderson,
Iowa Agricultural Experiment Station

The influence of eight different protein supplements on the egg production of White Leghorn pullets and hens was measured by three different statistical procedures. The "all mash" method of feeding was used so that each hen received the same proportions of the ingredients in the mash mixtures. The rations consisted of basal mashes

and supplements as follows: Basal mash No. 1. 50 lbs. of ground wheat, 25 lbs. of ground oats, 25 lbs. of ground corn, 3 lbs. of bone meal, and 1 lb. of salt (1 lb. of cod liver oil in the winter). Basal mash No. 2 was the same as number one except that the proportions of corn and wheat were reversed. Oyster shell and gravel were fed free choice in all rations. The eight supplements in three groups were:

(1) dried milk (three levels—15, 10 and 5 percent);
(2) meat and bone meal (two levels—10 and 5 percent);
(3) three combinations of dried milk and meat and bone meal (5 and 5) (9 and 5) (5 and 8).

When the influence of the rations on pullet production was measured by analysis of variance of the average of annual production (October 1 to September 30) of pullets which lived for 12 months general significance between pens was not obtained. When the October production was eliminated on theoretical grounds and production was calculated on the basis of the number of eggs per pullet (for 11 months) significant differences between pens appeared. When yearling hens were distributed among the pens with respect to their previous production highly significant differences were obtained by the three methods of calculation. On the basis of average number of eggs per hen for 11 months the groups ranked as follows. "Milk" 152 eggs, "combinations" 139 eggs, and "meat and bone meal" 121 eggs. On the basis of percentage production per hen days the groups ranked as follows: milk, .45 percent, combination, .42 percent, and meat and bone meal .37 percent.

25. TOLERANCE LEVELS OF SELENIFEROUS GRAINS IN LAYING RATIONS

W. E. POLEY AND A. L. MOXON,
South Dakota State College

Laying rations containing 2½, 5, and 10 p.p.m. of selenium were fed for a period of five weeks to determine the amount of selenium required to adversely affect production, fertility, and hatchability of eggs.

With 5 p.p.m. of selenium in the laying ration the hatchability was not appreciably affected although there was some evidence of selenium poisoning. The characteristic wiry down was observed on several of the chicks which hatched as well as with those dead in the shell. With 10 p.p.m. of selenium, however, the hatchability of normal chicks decreased nearly to zero. The characteristic symptoms of selenium poisoning, such as short upper beak, edema of the head and neck, missing toes and eyes, and wiry down, were noted in a large percentage of the embryos.

No significant effect on body weight, egg production, or fertility was noted with any of the levels of selenium used in this study. It will be recalled that in a previous experiment a level of 15 p.p.m. of selenium resulted in considerable loss in body weight.

Those chicks which hatched when selenium was first used to the extent of 10 p.p.m. were weak, undersized, and a large percentage died during the first few days.

The toxic effects of selenium as affecting hatchability were first noted six days after seleniferous grains were fed. When affected grains were replaced with normal grains normality was restored in six or seven days and no apparent ill effects resulted.

26. THE VALUE OF SUCCULENCE IN POULTRY RATIONS

M. WAYNE MILLER,
Western Washington Experiment Station

Three rations were fed in duplicate to six lots composed of 60 Single Comb White Leghorn pullets each. Ration 1 received 5 percent artificially dried alfalfa as a sole source of green feed. Ration 2 received both artificially dried alfalfa and succulent greenfeed, while ration 3 was fed succulent greenfeed as the sole greenfeed supplement. The greenfeed supplement was kale for the first three 28-day periods, carrots for the second three periods, and lawn clippings for the last periods of the trial. Yellow corn and cod liver oil supplied additional quantities of vitamin A to bring the total vitamin A intake above the requirement of laying pullets. Results based on egg production, egg weight, mortality, body weight, and egg quality showed that the succulent quality of greenfeed is of no value in poultry rations that are supplemented with 5 percent dehydrated alfalfa and which supplies the vitamin A requirements of the pullets.

27. STUDIES ON THE IMPORTANCE OF MANGANESE IN THE NUTRITION OF POULTRY

W. D. GALLUP AND L. C. NORRIS,
Cornell University

Further evidence has been obtained of the physiological importance of manganese in the nutrition of poultry. At two weeks of age the average gain made, on a manganese deficient diet, by chicks

showing symptoms of perosis was greater than that made by the unaffected chicks. At the end of six weeks the average gain made by the unaffected chicks was the greater. The average six weeks' gain made by the unaffected chicks was less, however, than that made by chicks that received adequate manganese.

Growth of chicks from six weeks to maturity was retarded when the manganese content of their diet was reduced from 50 p.p.m. to 10 p.p.m. Bowing of the legs and unsteady gait developed in the chicks that received this low-manganese diet. An increase in the manganese content of the diet to 1,000 p.p.m. did not cause the development of observable toxic symptoms.

A few chicks developed perosis on diets containing 50 p.p.m. of manganese. These isolated cases which developed early in life could not be prevented by adding manganese in high concentration to the drinking water or to the feed.

Pullets on a diet containing 13 p.p.m. manganese produced less than half the number of eggs per pullet than did those on a diet containing 200 p.p.m. of manganese. The percentage hatch of the fertile eggs from the low-manganese group was also less than half that of the high-manganese group. The manganese content of eggs was markedly reduced below that of normal eggs or greatly increased above the normal amount by appropriate adjustments in the manganese content of the diet fed the hens. A possible relationship between the manganese content of the breeder diet and the susceptibility of chicks to perosis is under investigation.

28. STUDIES OF INDIVIDUAL LAYERS

D. C. KENNARD AND V. D. CHAMBERLIN,
Ohio Agricultural Experiment Station

Studies of dietary habits of individual layers reveal surprising variations. This might be expected in view of the fact that practically all information concerning poultry feeding is based upon flock averages which obscure the interesting variations of the individuals.

In free choice feeding wheat was generally preferred to corn or oats. One layer had a special liking for wheat bran. During 12 weeks in 73 percent egg production her bran consumption was 31.6 percent of total feed with a water intake 3.34 times the weight of feed. The 31 weeks following with 26 percent egg production she consumed 43.5 percent of total feed as bran with a water intake four times the weight of feed. During a third period of 41 weeks in 65 percent egg production this layer received a ration of free choice whole grains and a mash concentrate which reduced the bran intake to 5.1 percent. The water intake during this period was 1.67 times the weight of feed. Obviously the water intake was directly affected by the amount of wheat bran consumed.

The studies of individual layers disproved the popular belief that body weight declines during heavy egg production. Contrary to this, body weight was maintained or gradually increased during heavy egg production. Likewise feed and water intake was generally maintained until egg production ceased, after which there was generally a sudden interruption of feed and water intake which was usually followed by a decline in body weight.

29. MAINTAINING HIGH QUALITY IN EGGS

L. M. HURD AND E. Y. SMITH,
Cornell University

Research in recent years has shown that breeding, feeding, and management of eggs after laying affect the quality of eggs. A review of recent findings in regard to the factors which affect the quality of eggs from the time they are laid until marketed will be taken up in this paper.

Thus far observations show that temperature, humidity, age, frequent handling, odors, flavors, and washing have an important effect on maintaining or destroying egg quality. Best methods of overcoming these handicaps will be presented.

30. THE SIZE OF POULTRY FLOCKS IN 1930 AND 1935

S. A. JONES, *U. S. Department of Agriculture*

The poultry items of the 1930 census were broken down into size groups by counties, based upon numbers of chickens on hand, to show for each group (1) number of flocks; (2) number of chickens on hand (presumably at assumed date of census, April 1, 1930); (3) number of chickens raised and (4) sold in 1929; and (5) number of eggs produced and (6) sold in 1929. A similar breakdown of the 1935 census figures for items 1, 2, 3, and 5 (taken as of the presumed date of January 1) has recently been completed for the North Atlantic and Far Western States and for South Carolina, Florida, Ohio, Michigan, and Missouri. For the remaining States a breakdown was made of sample counties including approximately 10 percent of the flocks of each state.

The group size limits used were the same for both censuses.

The 1930 census was taken at an average date

probably some weeks later than the stated date of April 1, and possibly sometime in May, and that of 1935 was probably nearer February 1, than the stated date of January 1. As the size of farm flocks decreases rapidly during the early months of the year the problem of a proper comparison of the size groups and totals of the two censuses presents difficulties. The means adopted by the Bureau of Agricultural Economics to adjust the figures of the 1930 census to a January basis and the resulting comparisons of the adjusted figures with those of the 1935 census will be discussed.

31. INHERITANCE OF EGG SHAPE, SHELL COLOR AND SHELL TEXTURE

F. A. HAYS, *Massachusetts State College*

Eight generations of Rhode Island Reds in three lines have been produced. Normal egg shape appears to depend upon dominant genes though modifying influences may at times produce abnormal shapes. Shell color covers a wide range with varying blends which will be illustrated. Selective breeding will definitely produce deeper shades of shell pigmentation. Shell texture is an individual characteristic but does vary through the year. Thin shells and thin ends appear to depend largely upon inheritance when the state of nutrition is satisfactory.

32. LATITUDE AND SEASONAL EGG SIZE VARIATIONS

D. C. WARREN, *Kansas State College*

Data have been collected from 10 different localities extending from Florida to Nova Scotia. Individual egg size records were secured from experiment stations and egg laying contests. From such records, a curve of mean daily egg size was constructed for each locality together with the curve of daily maximum temperatures. The general form of the curve is dependent upon the physiological maturity of the birds of the flock and the summer temperatures. When the maximum daily temperatures consistently remain above 70 degrees Fahrenheit, the egg size curve begins to recede. Sharp rises of summer temperatures are usually accompanied by corresponding declines in egg size. Where birds do not encounter maximum temperatures higher than 70 degrees Fahrenheit, the maximum egg size is reached in July and August. Those birds subjected to high summer temperatures never reach the potential maximum egg size during the pullet year, except when continuing to lay very late in the fall when temperatures have fallen. The results definitely indicate that the summer decline in egg size encountered in many localities is due to high environmental temperatures and not to any fatiguing influence coming at the end of the laying year.

33. SOME EFFECTS OF ARTIFICIAL LIGHT ON TIME OF LAYING

L. E. CARD, B. R. BURMESTER, AND H. M. SCOTT, *University of Illinois*

White Leghorn pullets have been subjected to various lighting schedules and to several different intensities of illumination under controlled conditions in which all natural daylight could be excluded. Some of the effects to which specific attention was given were:

1. The effect of reversal of the natural day and night cycle.
2. The effect of shortening the interval between successive light or dark periods, to produce 23-hour, 22-hour, and 21-hour "days."
3. The effect of repeated changes from a 12-hour day to continuous lighting, and vice versa.
4. The effect of successive reductions in light intensity to a minimum level of less than one-tenth the initial illumination.

34. FORMATION OF CHALAZAE AND INNER THIN WHITE IN THE HEN'S EGG

R. M. CONRAD AND R. E. PHILLIPS, *Kansas State College*

In the magnum (the albumen-secreting portion of the oviduct), the white is deposited around the yolk as an apparently homogeneous gel. By the time the egg has reached the uterus, the layer of white adjacent to the yolk has liquefied, although the mucin content has not decreased. If the egg remains in the uterus until oviposition, the formation of the chalazae is accompanied by a decrease in the mucin content of the thin fraction. On the other hand, if the membranous egg is removed from the oviduct at the time it enters the uterus and is then surrounded by an artificial uterine fluid, a normal outer thin white develops, but no chalazae are formed and the mucin content of the inner thin does not decrease.

If an egg is treated in the same manner except that it is slowly rotated, normal chalazae develop and the mucin content of the inner thin white decreases as in a normally formed egg. This would indicate that the rotation of the egg in the uterus causes a segregation of the mucin of the inner

thin white forming the chalazae and the chalaziferous layer.

35. BREEDING FOR IMPROVED MEAT TYPE IN HIGH EGG LAYING STRAINS OF POULTRY

E. A. LLOYD AND DONALD R. CLANDININ, *The University of British Columbia*

University of B. C. strains of Barred Plymouth Rocks, Rhode Island Reds, and White Leghorns have been bred and selected since 1919 for standard qualities as well as egg production, with special emphasis on the body conformation of males. To coöperate with Dominion policy of meat grading, all breeding birds and progeny have been graded since 1935 into A, B, and C grades, according to plumpness, general meatiness, quality or fineness in bone, skin, and feathering. In young males special attention has been given to early feathering, rapid growth and early maturity, as birds were weighed every two weeks after 12 weeks of age.

Differences in meat grades are apparent in breeds and families within same. In females and males respectively, the Reds rated 60 and 55.3 percent; the Rocks 55.6 and 71 percent; the Leghorns 51 and 66.6 percent in the top grade, A. Thus the Rock males and Red females are outstanding in meat type. Superior meat qualities appear to be inherited, and more characteristic of certain high producing families within the breeds. The deeper-bodied, shorter-breasted, slab-sided females laid no more eggs than the plumper-breasted, rounder-bodied females. The deeper-bodied males and females were graded B or lower.

No correlation was found between age to sexual maturity and egg production; meat grade and egg production; body size and egg weight; body size and egg production.

Such bred-to-lay strains, with early feathering, rapid growing characteristics, appear to be suitable for table purposes. Further progeny testing and selection gives promise of further improvement of meat type in high egg laying strains.

36. DEVELOPING A POULTRY GRADING PROGRAM IN IOWA

A. D. ODERKIRK, *Iowa State College*

The assembling of poultry upon a more economic basis, involving grading of market birds, is receiving a greater emphasis in the Middle West than it has in the past.

In the development of a grading program in Iowa which was attempted for the first time as a statewide objective during 1936, the quality grades used were patterned after the Chicago live market grades for no. 1 and no. 2 birds. Uniformity of weight classifications was largely ignored by market agencies who emphasized the carcass quality factors involved in grading.

The college extension service, in assisting and advising market agencies regarding poultry grading, has considered the following steps as fundamental to the success of such a program.

1. Considering the interests of three groups in planning a long time program, namely the producer, the market agencies, and the consumer.
2. Analyzing the market structure in the state and the attitude of both producers and market agencies toward grading. A survey of the attitude of market agencies, both coöperative and private industry was taken in 1937 to secure detailed knowledge which could be used in formulating a long time program of poultry marketing.
3. Preparation of materials and method of presentation are the important phases in extension work after the fundamental information is made available. In our work thus far, actual demonstrations of live and dressed poultry grading together with explanations of price trends and market demands have been found to be of most value to both producers and market agencies.

Our experience indicates the need for careful planning before launching any program or before assisting in steps which have been taken by any special groups to further their particular interest. As a surplus producing area, the producers' interests, the kind and volume of their product should be known at the outset. More factual information about consumer demands for poultry are needed. Between these extremes the marketing practices must be adapted until changes in basic knowledge and education can change one or all of these groups to more economic methods.

37. GYNANDROMORPHISM IN THE FOWL

F. B. HUTT, *Cornell University*

Study of a living bilateral gynandromorph and its subsequent dissection indicated that it arose from loss of an X-chromosome in a zygote originally male. The right (♂) half of the skeleton exceeded the left in size by approximately the average difference between males and females. The plumage and shank color of the right side were lighter than on the female side as is to be expected in any comparison of BB and B-genotypes. Plumage structure was predominantly female, but many saddle feathers on the right side were of the male type.

The bird originally sold as a pullet, later crowed and showed male psychosexual characteristics and toward death was more like a female. It produced motile spermatozoa, apparently normal but incapable of fertilizing eggs following artificial insemination. On autopsy a testis and normal vas deferens were found on the right side, an ovary, oviduct and rudimentary vas on the left side. The case is considered to refute the theory that lateral hemi-hypertrophy is the cause of avian gynandromorphism.

38. SEXUAL DIMORPHISM IN DOWN COLOR OF RED-SPLASHED WHITES

JOSEPH P. QUINN, *U. S. Department of Agriculture*

Observations on the down color and sexes of 738 Red-Splashed White chicks (mutation from Rhode Island Reds) indicate sexual dimorphism. The chicks were classified, according to down color characteristics, in four groups: white, white with red spot on head, white with two red head spots, and white with red and black head spots. In the last mentioned case, the chicks with one or more red head spots also carried a black head spot in the center of one of the red spots, usually the upper one.

In the white, or non-spotted chick group, two males to one female were observed. In the chicks with two or more red head spots, there were two females to one male. A similar preponderance of females over males has also been observed in chicks carrying both red and black head spots. In chicks with one red head spot, males and females appeared in about equal numbers.

39. PROGENY TEST OF CROSSBRED CHICKENS, S.C. WHITE LEGHORNS AND RHODE ISLAND REDS

CHARLES W. KNOX AND MARLOW W. OLSEN, *U. S. Department of Agriculture*

Three ways of obtaining hybrids are discussed, crossing individuals of different genera, species, or subspecies, crossing inbred individuals of different inbred lines, and crossing individuals of different breeds and varieties. Data were collected on different groups of hybrid pullets obtained by the last mentioned method. The progeny of the different crosses were compared among themselves and with Single Comb White Leghorn and Single Comb Rhode Island Red pullets.

The summarized results were as follows:

1. The quality of the parental stock has considerable influence upon the quality of the hybrid progeny.
2. Different strains of the same varieties of chickens may produce different results in the hybrid progeny obtained.
3. The results from the parental crosses studied in this investigation indicate that the average hybrid was only superior in the case of early body weight.
4. The results showed that the average hybrid chicken from purchased stock did not do as well in regard to egg production as did the average of the White Leghorn and Rhode Island Red stock. Reciprocal crosses between broody and non-broody breeds and strains gave different results indicating sex-linked broody factors.
5. The best hybrid progeny were obtained from crosses between Rhode Island Reds and Barred Plymouth Rocks and between Rhode Island Reds and White Wyandottes. These crosses obtained from good quality parental stock produced practically as well as the standard-bred White Leghorns and Rhode Island Reds.
6. The viability of the hybrids was superior to that of the standardbred chickens.
7. The hybrids had a considerably greater incidence of broodiness than either the White Leghorns or Rhode Island Reds.

40. MULTIPLE DETERMINATION OF THE ANNUAL EGG RECORD

I. MICHAEL LERNER AND LEWIS W. TAYLOR, *University of California*

In pursuance of studies on the contribution of various inherited factors to the annual egg record, a biometric analysis of egg production records of two series of non-pausing Single Comb White Leghorn pullets is presented. As measures of the time factor, age at first egg and age at last egg are adopted and net winter, spring or summer rate are combined with these singly to determine how much of the variability in the annual egg record is accounted for by the three factors. The proportion is found to be from 0.553 to 0.914, with standard errors of estimate from 12.9 to 21.4 eggs for the different combinations. An attempt to evaluate the relative contribution of each of the independent observables to the variance of the annual egg record is made. Thus, when production for the biological laying year is considered, age at last egg is found to be the most important single contributing factor, with age at first egg next and the three measures of rate last in importance. When 365-day production is considered, the results are not as clear cut, with rate assuming

the greatest importance for some of the combinations and age at last egg for others.

41. THE INFLUENCE OF VARIOUS FACTORS ON FIRST YEAR EGG PRODUCTION IN TURKEYS

V. S. ASMUNDSON, *University of California*

The first year egg records of 238 turkeys trapnested in 1934, 1935, and 1936, and hatched in April and May of the preceding year, were analyzed statistically. Date at last egg (and age at last egg), which was used to measure persistency, was found to be more closely correlated with total egg production than the other factors considered. Date of first egg (in days from the first of the calendar year in which the record was made) was adopted as the measure of maturity since there was a higher correlation between date of first egg and total egg production than between age at first egg and total egg production. Other factors which are correlated with egg production include net rate and total length (but not number) of pauses. Date of first egg, date of last egg and net rate are independent variables, that is there is no correlation between them.

42. HISTOLOGICAL BASIS FOR DIFFERENCES IN CONSISTENCY OF FIRM EGG-ALBUMEN

RANDALL K. COLE, *Cornell University*

A histological study of the oviduct of the fowl, directed towards the determination of the structural bases for the variations seen in the condition of the firm albumen from fresh eggs, has shown that variations in the microscopic structure of the albumen-secreting portion of the oviduct are to a certain extent responsible for the differences observed in the condition of the firm albumen. These differences are consistent and are in accordance with the present knowledge concerning egg-albumen and its secretion.

By applying histological methods of technique to egg-albumen, which had been coagulated by heat, the structural differences between egg-albumen of good and poor consistency have been demonstrated. Stained sections, eight microns thick, of all the layers of the egg-albumen, show that the condition of the firm albumen is dependent upon the number, compactness and distribution of mucin-like fibers. The source of these mucin-like fibers was seen to be restricted to the albumen-secreting region of the oviduct, especially the glands in the surface epithelium of the posterior half of that region. Differences in the size of these glands, accompanied by the production of different amounts of the mucin-like material, are responsible for the observed variations in the condition of the firm albumen in the fresh eggs.

43. ON THE NATURE OF "MEAT SPOTS" IN EGGS

B. R. BURMESTER, *University of Illinois*

So-called "meat spot" eggs were identified by candling. The spots were removed, fixed, and sectioned, and stained with various biological stains. Microscopic examination was then made in an effort to identify the tissue or tissues involved in order to determine the origin of the meat spots.

44. INDUCED OVULATION IN THE FOWL

H. M. SCOTT AND F. R. STEGGERDA,
University of Illinois

The average interval between an oviposition occuring after 2:00 P.M. and the succeeding ovulation was determined for a control group of hens. This interval was compared with that of experimental groups which were injected with antuitrin and the serum of pregnant mares immediately following oviposition.

45. THE INFLUENCE OF VARIOUS HORMONES ON THE LEVEL OF BLOOD CALCIUM IN THE FOWL

MARGARET ALTMANN, *Cornell University*

In attempts to discover the endocrine basis for the rise in blood calcium associated with ovulation, the effects of extracts of various endocrine glands and tissues were measured.

A strong rise in serum Ca above the normal level for non-laying birds (70-140 days old) was obtained by injections of parathyroid extract, Progynon B (Schering), egg yolk, liver extract, and a still greater rise by the simultaneous injection of anterior pituitary extract and egg yolk. Egg yolk also raised the blood Ca level of capons. The follicle-stimulating fraction of the anterior pituitary hormone injected with parathyroid extract did not give any greater rise of serum Ca than that from the parathyroid extract alone.

In similar birds the blood Ca was significantly decreased by injections of the thyrotropic fraction of the anterior pituitary hormone and by simultaneous injections of extracts of the whole anterior pituitary and parathyroid extract, while anterior pituitary extract alone caused no change in serum

Ca level. The elevated blood Ca level of normal laying hens was significantly decreased by injection of Progynon B and by egg yolk.

46. A COLORIMETRIC METHOD FOR THE STUDY OF MELANIN IN FEATHERS

DEWEY G. STEELE, *Connecticut State College*

The quantitative determination of the melanin content of feathers by any of the methods recommended thus far is tedious and not as accurate as one would desire because the separation of melanin from the degradation products of keratin following hydrolysis by either hydrochloric acid or caustic is difficult. By the method outlined below it is possible to express the melanin content of several well-known color types in the fowl, not in percentage values, but in terms of the light blocking power of a dilute solution of the digested feather sample. The steps in the procedure are as follows:

(1) Thorough washing of the feather sample, followed by drying to constant weight.

(2) Digest the feathers by boiling the sample for fifteen minutes in 2.5% NaOH. Approximately 100 cc. of caustic for a one gram sample is a convenient volume to use. The boiling is done in a flask connected with a reflux condenser. Immediately following the digestion process the contents of the flask are cooled by immersing the flask in cold water.

(3) A small portion, such as one cc. or five cc., of the colored liquid is diluted with sufficient 2.5% NaOH to give a faintly colored test solution of the concentration, one gram of feathers in 8,000 cc. of caustic solution.

(4) The light blocking power of the test solution is now measured in an electrometric colorimeter.

Consistent and reproducible results have been obtained by this procedure, and they will be presented in tabular form. These results will demonstrate the quantative effects of several so-called qualitative color factors.

48. INTEGRATED PROGRAMS

WILLIAM KOHLMEYER, *Purdue University*

Few people can be specialists in several different lines of work. Extension teaching can be made more effective by coöperating with other subject matter specialists.

Profitable poultry production is based upon knowledge of nutrition, pathology, engineering, economics, genetics, embryology, marketing, management and a number of other branches of learning. Few, if any, poultry specialists are highly trained in all these related fields. It would seem that more people might be reached and more effective extension work accomplished by working closely with other departments and agencies.

The following list includes a number of departments with which coöperation would seem desirable.

1. Agricultural Engineering.
2. Farm Management, Economics, Marketing.
3. Veterinary Science.
4. Home Economics.
5. Exhibits, special programs.
6. Agronomy.
7. Chemistry.
8. Entomology.
9. State Regulatory Officials.
10. Poultry Improvement Organizations.

What forms of coöperation have been used in the past? How can such programs be improved and enlarged in the future?

49. NATIONAL AGRICULTURAL PROGRAMS AND THEIR EFFECT ON STATE PROGRAMS

H. L. SHRADER, *U. S. Department of Agriculture*

Many agricultural programs within a subject-matter classification could be called nation-wide, for example, the culling campaign of 20 years ago, cow testing associations, grow healthy chick campaigns, and more recently the National Poultry Improvement Plan. Such programs are based on subject-matter findings and strike at fundamental needs seeking increased efficiency.

Following this type of national programs there was a shift from production subjects toward more economic material. The technique and interest in outlook were developed. Programs of subject matter were organized and extended with the help of the county agricultural agents and results were measured in adopted practices.

The depression showed the need for a national program to raise the farm income. There are now three action programs on a national scale, the Agricultural Adjustment Administration, Soil Conservation and Rural Rehabilitation. County agents are busy with work sheets and adjustment checks and county allotment committees. Economic conditions have changed. Marketing agreements are in the offing. County agents are expected to reflect the national viewpoint. More grass and less grain, the land purchase program a shift of the poultry population from the drought area, rapid development of the number of turkeys raised, all have a

direct bearing on the poultry programs in the States.

The influence of other agencies must be mentioned. Production credit under the Farm Credit Administration. The Rural Rehabilitation organization is fostering farm and flock management practices on a group of farmers which the Secretary of Agriculture has maintained that the Extension Service has neglected. The Tennessee Valley Authority has established demonstration counties. The W.P.A. furnishes labor to do blood testing in one State and the N.Y.A. summarizes demonstration farm flock records in several States. All such programs have worked toward a broader aspect of the poultry program and we must fit our plan of work in with these changes in conditions.

50. STANDARDIZATION OF METHODS IN CONDUCTING CHICK NUTRITION EXPERIMENTS

J. S. CARVER AND VICTOR HEIMAN,
Washington Agricultural Experiment Station

Many of the difficulties encountered in the analysis of quantitative experiments with chicks may be overcome by standardizing the experimental technique and by setting up the experiment so that the application of statistical methods may be used in interpreting final results. In work conducted at this Experiment Station it has been possible to eliminate the influence of mixed sexes by using day-old White Leghorn sexed male chicks exclusively. This provides a larger number of experimental animals than is ordinarily used at a lower cost. This method has been successfully applied to the quantitative measurements of vitamin A, vitamin D, vitamin G, and the gross protein value.

Twice as many chicks are started as will be required for the experiment. These are depleted of their reserve store of the nutritive factor under study during a preliminary depletion period. In studies of vitamins A, D, and G, the same general basal ration is used having a protein content standardized at 20.0 percent, a calcium content of 1.0 percent, and a phosphorus content of 0.7 percent. The ingredients of the rations are subjected to a preliminary chemical analysis and the mixed rations for each lot are analyzed before being fed. At the end of the depletion period the 50 percent of the chicks most nearly approaching the mean weight of the entire group are distributed in replicate lots among the experimental lots, such that each pen in the experiment contains the same number of birds from each of the weight classes. The length of the period of the experiment varies from two to three weeks after depletion, depending on the factor being studied. In experiments where replicates do not check, the experiment is discarded. The experiment, set up in this manner, is analyzed by the method of analysis of variance outlined by Snedecor. The results are interpreted by interpolating the relative amount of the factor under study on a curve of a reference standard fed at suboptimum levels.

51. EXPERIMENTAL TECHNIQUE IN FATTENING AND COMPARATIVE VALUE OF FATTENING RATIONS

H. S. GUTTERIDGE,
Dominion Experimental Farms, Ottawa

Allotment at random to positions in individual cage fattening batteries was found to be equally as satisfactory where sufficiently large numbers of birds were used (forty for each group) as randomization restricted according to initial weight. The adjustment of means by the partial regression of initial weight upon gains was negligible where complete randomization had been used.

Weight gains and increase in fat were the most important criteria for judging efficiency in finishing for market. Weight gain was a poor indication of increase in fat (corr. $r = + 0.251 \pm .076$). Increase in fat was determined by taking fat samples before and after fattening. The increase in fat obtained was directly proportionate to actual grade of birds according to Canadian Government Standards.

Differential deposition of fat, e.g., whether deposited in skin and subcutaneous tissue in breast tissue or abdominally, was of no value as a criterion of efficiency of different cereals in fattening since different cereals caused deposition of fats in these areas at a practically constant ration, viz., (breast) 1: (skin and subcutaneous) 32.7: (abdominal) 48.0. Between skin and subcutaneous, and abdominal fat $r = + 0.93 \pm .007$ and between breast and skin and subcutaneous and abdominal $r = + 0.36 \pm .138$ and $r = + 0.16 \pm .154$ respectively. Weight gains were adjusted for the effect of varying feed consumption by the method of partial regression in comparing effect of different feeds or treatments.

A fattening mixture fed dry ad lib with skimmilk to drink ad lib was relatively inefficient (24.4 percent difference).

Crate feeding (capons) was definitely superior to pen feeding (difference 40.4 percent).

Potatoes raw or cooked and mash (equal weights) were definitely inferior to mash alone (differences 6.1 percent and 22.8 percent).

Corn gave equal gains to wheat but on a considerably lower feed consumption (difference 17.1 percent).

Addition of 10 percent meat meal to the cereal ration gave increased gains (difference 18 percent).

A feeding period of 15 minutes was as efficient as one of 30 minutes.

Addition of 5 percent of ground oyster shell increased both feed consumption and gain by 10 percent.

Addition of 5 percent of molasses had no apparent effect.

Addition of 5 percent of mutton fat did not materially affect feed consumption but increased gain by 19 percent, efficiency of use of feed by 30 percent, increase in body fat by 17 percent and grading of the birds by 17 percent.

52. A METHOD FOR DETERMINING THE GROSS VALUE OF PROTEIN CONCENTRATES

VICTOR HEIMAN AND J. S. CARVER,
Washington Agricultural Experiment Station

A method has been developed for measuring the gross protein value of feeds. This method consists essentially of depleting the protein reserve of the chicks for a period of two weeks by feeding a suitable chick ration, complete in all of the known nutrients except protein. The level of protein in this depletion ration is eight percent, and is derived from plant sources. At the beginning of the experimental period the 50 percent of the chicks having body weights nearest the mean body weight of the group are selected and divided into duplicate lots of 15 chicks each. The experimental rations are then given and these consist of the depletion ration to which is added a sufficient amount of the supplement to bring the protein content to 11 percent. The experimental period is two weeks and the results are compared with commercial casein which is arbitrarily given a gross protein value of 100. Numerous experiments have been conducted using this method of determining protein value for a variety of protein concentrates.

53. FURTHER STUDIES ON THE RELATIONSHIP OF BLOOD CALCIUM TO THE MINERAL METABOLISM OF THE HEN

H. J. DEOBALD, J. B. CHRISTIANSEN, E. B. HART, AND J. G. HALPIN, *University of Wisconsin*

The oviducts of three 8-week-old pullets were excised and various portions of this organ removed from 12 other pullets. The blood calcium curve was normal at maturity, showing the characteristic rise, peak, and subsequent fall to an intermediate level. Within 14 days after the peak in the blood calcium curve the pullets were adjudged to be laying by the usual criteria. The pullets appeared to be normal in every respect. It was evident that the oviduct *per se* had no influence on the mobilization of calcium into the blood before the pullets came into lay.

Parathyroid extract injected into hens on a low calcium diet or on a diet to which $FeSO_4$ was added did not cause the characteristic rise in blood calcium. The hens on the low calcium ration did not respond even when $CaCO_3$ was administered by capsule eight hours before injection. The calcium available for mobilization by the parathyroid hormone apparently had been exhausted. Low calcium and low phosphorus ($FeSO_4$ ration) diets produced similar blood calcium curves in the hens. Both rations inhibited egg production and both caused a negative reaction to the parathyroid hormone.

Analysis for total phosphorus and total calcium in whole blood was made preceding and during the first portion of the laying period of three pullets. The total phosphorus in the blood showed a direct correlation with the blood calcium curve, except at the high peak immediately preceding the laying period.

54. THE CALCIUM AND PHOSPHORUS BALANCE OF LAYING HENS

C. L. MORGAN, *South Carolina Experiment Station*

Calcium and phosphorus balances have been made on pullets in their first laying year. With the usual laying ration the hen receives sufficient phosphorus to meet her requirements as indicated by the cumulative positive phosphorus balance. During heavy egg production the hen is in most cases in negative calcium balance, particularly during the first few months of lay. A pause in egg production may be associated with a cumulative negative calcium balance, however, good layers restore their calcium supply and remain in production. The return to positive calcium balance may be due to an internal adjustment of calcium output which results in a reduction of the amount of egg shell secreted. A high producing hen utilizes a greater percent of her calcium intake in egg production. Loss of calcium does not appear to be associated with molt. Calcium utilization may be an individual characteristic of the hen.

55. A NUTRITIONAL DISEASE OF CHICKS CAUSED BY FEEDING DRIED EGGS

W. C. TULLY, *Sunset Feed & Grain Company*

Experiments are reported with 22 lots of chicks fed commercial dried egg, and egg white, where these products were used both as the only source of animal protein and with various supplements.

When a ration containing 15 percent of commercial dried egg is supplemented with 10 percent of dried buttermilk and 5 percent of meatscraps the incidence of a pellagra syndrome is very slight and growth is excellent.

Dried egg fed to growing chicks as the only source of animal protein resulted in highly significantly better growth than that produced by a ration containing the same amount of protein from dried buttermilk. While this increased growth may not have been due altogether to the protein the addition of yeast to the dried egg protein ration still further increased growth to a highly significant extent.

Dried egg white even when supplemented with yeast, milk, or combinations of these, in rations believed otherwise complete failed to produce good growth and chicks were affected with a very severe pellagra syndrome. Similar results were produced by feeding either raw or commercial dried egg white. However, dried egg fed at the same protein level produced incomparably better growth and the pellagra syndrome was almost absent.

Hemoglobin studies are reported for chicks from seven of the lots and the first report on the serum albumin and globulin content of chick blood is given.

56. DIURNAL CHANGES IN THE GASEOUS METABOLISM OF THE CHICKEN

H. G. BAROTT, *U. S. Department of Agriculture*

Changes in the rate of the oxygen consumption of the chicken during 24-hour periods, which were observed in energy metabolism studies at the National Agricultural Research Center, Maryland, are discussed.

57. AN INFORMAL ROUND TABLE DISCUSSION OF TEACHING METHODS AND PROBLEMS

E. M. FUNK, *University of Missouri*

A. Prerequisites.
   1. What should be the prerequisites for a course in Poultry Husbandry?
   2. How much theory should be presented in a general course?

B. Courses.
   1. Undergraduate.
      (a) Required.
      (b) Elective.
   2. Graduate.
   3. Are we offering courses in Poultry Husbandry at the expense of training in basic sciences?
   4. Should short course students receive a different type of teaching in Poultry Husbandry courses?
   5. What is the distinction between a freshman course in Poultry Husbandry and an advanced course in the same field?
   6. What should we expect Agricultural students to know about poultry?
   7. Courses for students who have had Poultry in Vocational Agriculture?

C. Laboratory Excercises.
   1. How and where may we employ field trips in teaching poultry husbandry?
   2. What laboratory excercises should be offered in the course in general Poultry Husbandry?
      a. How many exercises in judging?
   3. How might a laboratory exercise in feeding be organized and carried out in order to teach the students what they need to know about poultry feeding?
   4. Same as 3 applied to market eggs and poultry.
   5. Same as 3 applied to housing.

58. SUSCEPTIBILITY AND RESISTANCE OF SOME STRAINS OF CHICKENS TO FOWL LEUCOSIS

H. L. WILCKE, C. D. LEE, AND CHARLES MURRAY, *Iowa State College*

The results of three years' work with pedigreed S. C. White Leghorns have been summarized, and indicate that there are marked differences in the susceptibility or resistance of the progeny of individual dams to injections of the causative agent of fowl leucosis. There is also evidence to support the conclusions of other workers that there are differences in the resistance or susceptibility of the progeny of individual dams to fowl leucosis when the progeny are exposed to the disease by contact only. The difference for the various sires used are not conclusive.

59. EXPERIMENTS IN THE TRANSMISSION OF FOWL PARALYSIS BY INOCULATION

J. R. BEACH, *University of California*

A report of the results of attempted serial passage of two strains of fowl paralysis by intravenous injections, extending over a period of 2½ years.

The original material of both strains came from typical natural cases of paralysis, one in White Leghorn and one in Rhode Island Reds. The data are analyzed to show the incidence of lymphoid infiltrations of nerve and other tissues among the inoculated and control chickens with respect to (1) age at time of inoculation; (2) type of material used for inoculation; (3) the incidence of lymph-

oid infiltrations among all experiment chickens coming from the same lot of normal stock; and (4) the ancestry of the individual chickens.

60. RELATIONSHIP BETWEEN COLON BACILLI AND CECAL COCCIDIOSIS IN THE PRODUCTION OF CHRONIC COCCIDIOSIS

G. L. OTT, *University of Wisconsin*

For a period of three years, attempts have been made to determine any possible relationship between secondary bacterial invasion following an acute attack of cecal coccidiosis in chickens and "asthenia," or "going light."

While it was comparatively easy to isolate colon bacilli from the livers and spleens of birds following experimental infection with *Eimeria tenella*, great difficulty was experienced in producing artificial liver lesions, as charaterized in spontaneous cases of chronic coccidiosis.

By artificial inoculation per os of bacilli isolated from the livers of birds suffering from "chronic" coccidiosis every day following the experimental inoculation with oocysts of a pure line of *Eimeria tenella*, it was determined that bacterial invasion occurred on the third and fifth days following coccidial infection, at which time, the first and second generations of merozoites, respectively, were entering new epithelial cells. The greatest amount of invasion occurred on the fifth day following coccidial infection, at which time effusive hemorrhages and sloughing of wide areas of epithelium occurs in the cecal pouches.

The greatest success in the artificial production of liver lesions was reached when the birds were kept on a vitamin-free, low maintenance diet. Lesions varying in size were attained upon the feeding of *Escherichia coli* on the third and fifth days following coccidial infection.

The chickens were tested periodically for BWD, although coming from a BWD-free, accredited flock, but all tests were negative.

61. FEEDING SULPHER TO CONTROL COCCIDIOSIS IN POULTRY

C. A. HERRICK AND C. E. HOLMES,
University of Wisconsin

The feeding of sulphur has been found to prevent to a very large degree the development of cecal coccidiosis in chickens.

Sulphur was fed in varying amounts up to twenty percent of the ration. The chickens receiving the smaller amounts were not so adequately protected from coccidiosis as were those receiving the larger amounts but were much more resistant than those receiving no sulphur.

Sulphur has been found to be useful only as a preventative; it has not proved successful in reducing the mortality from coccidiosis if fed after symptoms were apparent in the infected animals.

The relation of sulphur to the rate of growth and its effectiveness to prevent coccidiosis when added to rations with varying protein levels will also be discussed.

62. SHORT INTERVAL TESTING FOR THE ERADICATION OF PULLORUM

C. A. BOTTORFF,
N.H. Agricultural Experiment Station

Short interval testing of badly infected flocks for the eradication of Pullorum is not practical where hatching eggs or baby chicks of equal breeding qualities can be purchased from Pullorum Clean or Pullorum Passed flocks.

The eradication of Pullorum in a badly infected flock can be best accomplished hy short interval testing of smaller units that are entirely separate from the main flock. No unit should be used for breeding purposes until at least two or more non-reacting tests have been secured. In case of only a few douhtful or suspicious reactors, a careful laboratory post mortem should be performed and if S. pullorum cannot be isolated from these birds, they should not be classed as reactors.

The testing of an infected flock should begin in August or September and continue at approximately monthly intervals. According to these studies, the number of tests required to secure one non-reacting test varied from as low as two to as high as nine tests. The number of tests necessary to secure a Pullorum passed flock depends somewhat upon the distribution and severity of the infection in the flock.

Suspicious or positive reactors in Pullorum Clean or Pullorum Passed flocks should be retested and a careful laboratory post mortem made before these birds are classed as infected. If less than 5 or 6 positive reactors are found in a Pullorum tested flock, they should be autopsied and if S. Pullorum cannot be isolated from these birds, the flock should be classed as Pullorum Passed.

63. A MODIFIED PIGEON-POX VACCINE-VIRUS FOR FOWL-POX IMMUNIZATION

R. E. LUBBEHUSEN, *University of California*

A report of the results of four years of experimentation to produce a modified vaccine-virus for fowl-pox, possessing the immunizing efficiency of

chicken-pox virus and the non-depressant properties of pigeon-pox virus vaccines.

In this work, three series of passages of two strains of pigeon virus through chickens have been made. Such serial passage resulted in a gradual adaptation of the pigeon virus to chickens and a corresponding decrease in its virulence for pigeons. In the first series, this adaptation to chickens was complete after 30 serial passages; in two subsequent series the adaptation was slower and still incomplete after 70 passages. Modification or adaptation of the pigeon virus was indicated by changes in the type of tissue reaction following cutaneous inoculation of chickens as well as similar evidence of decreased virulence for pigeons. The immunizing value of the serial passage viruses has been regularly tested by exposing chickens to fowl-pox infection at various times after vaccination with the modified virus by the follicle infection method. The depressant effect of the modified virus on chickens following vaccination has been compared with that caused by fowl-pox virus by observing (a) the rate of growth and mortality of groups of chicks over a period of three months following day-old vaccination and (b) the effect on egg production following vaccination of flocks of laying pullets. The experiment data to date indicate that the modified pigeon-pox virus possesses advantages over both types of vaccine-virus in use at present, i.e., unattenuated chicken virus and pigeon virus vaccine for fowl-pox immunization.

64. THE EFFECT OF TEMPERATURE AND TIME ON THE INTERIOR QUALITY OF EGGS

VICTOR HEIMAN AND L. A. WILHELM,
Washington Agricultural Experiment Station

The purpose of this work was to study the influence exerted by temperature over varying periods of time on the albumen index of eggs. Preliminary to this work a flock of Single Comb White Leghorn pullets were classified on the basis of the albumen index of the eggs produced into the three following ranges—low range from 110 to 129, intermediate range from 140 to 149, and high range from 160 to 180. Seven dozen eggs from each of these three classifications were placed in storage at 30° with a relative humidity of 75 to 78. These eggs were removed at intervals and the change in the albumen index and the loss in the egg weight were observed for all eggs. The same procedure was followed at temperatures of 50°, 70° and 90°. The maximum storage periods were: 192 days at 30°, 96 days at 50°, 32 days at 70°, and 8 days at 90°.

The results of this work indicate that the eggs having high, low and medium albumen index maintain approximately the same ratio of quality throughout the storage period. It was also observed that the loss in quality is extremely rapid at the beginning of the storage period and after prolonged storage the rate of fall in the albumen index is much slower. The rate of deterioration simulates the logarithmic curve.

65. A SIX-MONTHS' PROGRESS REPORT OF DAILY OBSERVATIONS ON INTERIOR QUALITY OF EGGS PRODUCED BY INDIVIDUAL HENS

L. A. WILHELM AND VICTOR HEIMAN,
Washington Agricultural Experiment Station

Three lots of twenty White Leghorn pullets just coming into production were housed October 15, 1936. These pullets were trapnested, the eggs gathered hourly, taken immediately to a cooler where they were held from twelve to twenty-four hours. The following observations were made on each egg: egg weight, yolk color, and albumen index. Daily maximum and minimum temperatures were taken.

Since the beginning of the observations, there has been a gradual but consistent fall in the mean albumen index in the eggs produced by the replicate lots. Egg production has varied directly with the temperature in the pens. Observations were also made on the relationship between the intensity of production and the albumen index and the yolk color; on the quality of the egg; on the relation to position of the cycle; and on the time of day the egg was produced.

67. THE TURKEY SERVICE AS AN EXTENSION ACTIVITY

E. Y. SMITH, *Cornell University*

The Federal census and letters from turkey growers had indicated that the turkey industry in New York State was rapidly increasing. The growers had also indicated that they needed, desired and expected help from the Poultry Department of the State College.

Statewide meetings of turkey growers were held at the Cornell Poultry Department in 1931 to study the turkey situation and to determine the problems confronting the producers.

From these meetings the turkey situation in this state appeared to be as follows:

(1) The growers were facing difficulty because of a change in the market demands relative to the size of the bird.

(2) Old ideas and practices prevailed relative to breeder selection, breeder management, incubation, brooding and rearing, finishing, and preparation for market.

(3) There existed little uniformity in their practices relative to any of the phases of turkey production.

(4) Mortality of the growing poults ranged from 5 percent to 100 perecnt from the date of hatching to marketing time, and averaged about 50 percent for the state.

The service was organized as a campaign with a definitely enrolled group of turkey growers; and was to be conducted jointly by the turkey growers, the local County Farm Bureau, the Central Farm Bureau office, and the Poultry Specialist at the College.

Enrollment in this campaign has grown from 100 members in 1932, to over 2,700 in 1937. More uniform practices are being followed by the growers. Fairly accurate records are kept which show a rapid and consistent decrease in young bird mortality.

Our close proximity to the consumer has enabled us to study consumer prefereoce, and this study has caused changes in our production practices.

68. BODY CONFORMATION OF THE LIVE MARKET TURKEY

R. GEORGE JAAP, *Oklahoma A. & M. College*

In Oklahoma the optimum time to market turkeys appears to be from 26 to 28 weeks of age. Regardless of the manner in which turkeys are fed and managed there are always rather large differences in body conformation. Since it is only the heritable differences which make possible any permanent improvement in body shape, it is important to evaluate the influence of heredity under different environmental conditions.

The records to be reported compose a survey of the amount of variability which may be expected in market birds. Approximately 1,400 turkeys reared on the Experimental Farm were weighed and certain linear measurements taken as the different age groups reached approximately 27 weeks of age. The different varieties studied are Bronze, Black, Bourbon Red, Narragansett and White Holland. Since each body measurement is treated in such manner as to become an indication of the entire conformation, the value of different measures shall be discussed. The influence of sex, age groups, variety and fleshing on each of the different measurements is given for this population.

69. THE EFFECT OF THE LEVEL OF PROTEIN INTAKE ON THE GROWTH AND FEED UTILIZATION OF TURKEYS

JOHN C. HAMMOND AND STANLEY J. MARSDEN, *U. S. Department of Agriculture*

Seven experimental lots of Bronze turkeys were reared with access to poor grass range for a period of 28 weeks. Their diets were mash and scratch fed ad libitum. The seven mashes fed varied in protein content from approximately 18 to 30 percent by increments of two percent.

It was found that the protein content of the mash had no consistent effect on the quantity of feed required to produce a pound of gain. The decrease in efficiency of feed utilization was found to be a linear function of live weight. The ratio of mash to scratch consumed varied inversely as the protein content of the mash. The ratio of mash to scratch consumed decreased as the birds advanced in age. The total protein and animal protein consumed per pound of gain increased as the protein content of the mash increased from 18 to 26 percent, but were approximately constant as the protein content of the mash increased from 26 to 30 percent. The lot that received the mash that contained 18 percent of protein grew less rapidly and weighed less at 28 weeks than any other lot. The other six lots varied from each other but little in rate of growth or live weight at 28 weeks. The quantity of protein consumed had no consistent effect on mortality, or malformation of legs or breast bones.

70. FISHY FLAVOR AND ODOR IN TURKEYS THE EFFECT OF COD LIVER OIL (NOT U.S.P.) AND WHITE FISH MEAL

D. R. MARBLE, J. E. HUNTER, H. C. KNANDEL, AND R. A. DUTCHER, *Pennsylvania State College*

Twenty-six carcasses of turkeys fed cod liver oil-fish meal or both for varying periods of time were roasted in separate ovens and the degree of fishy flavor in the breast meat, thigh meat and drippings was scored by eighteen observers. Odor was scored for the carcasses as a whole. Fishy flavor and odor were observed in the roasted carcasses of turkeys 28 weeks of age fed either 1 percent of a poultry grade cod liver oil (not U.S.P.), 10 percent of vacuum dried white fish meal or both during the entire growth period. The combination of these two ingredients in the mash produced a more pronounced flavor and odor than when either was fed separately.

Three birds were removed from the pens re-

ceiving either cod liver oil, fish meal or the combination of both at 8, 4, and 2 weeks prior to slaughter and placed in the pen receiving the basal ration containing neither cod liver oil or white fish meal. The removal of both cod liver oil and white fish meal from the diet eight weeks prior to slaughtering time practically eliminated the occurrence of both fishy flavor and odor.

71. OHIO TURKEY MARKET NEWS SERVICE

RAYMOND E. CRAY, *Ohio State University*

The turkey business in Ohio has experienced such a rapid growth that many of the larger growers lack experience in the marketing of their crop. One problem which complicated orderly marketing of the crop was the grower's lack of information relative to prices being paid in the country as well as at the terminal receiving points.

Three years ago the Ohio Turkey Market News Service was organized for the purpose of supplying turkey growers with market information. Turkey growers in all sections of the state coöperated by sending in each Saturday a report of the sales of turkeys they made during the previous week, as well as other sales in the community. These reports were summarized on Monday and radio releases sent to various radio stations in the state, and a summary of the reports mailed to each grower along with a report blank for the succeeding week.

During the past year over 150 turkey growers coöperated in sending in weekly reports and the summaries of these reports were broadcast over 14 radio stations within the state. The turkey marketing news service has given growers information on prevailing prices over the state and has thus been of material assistance to their determining what was a fair price for their crop.

72. THE CONTENT AND FUNCTION OF A SURVEY COURSE IN POULTRY MANAGEMENT

F. E. MUSSEHL, *University of Nebraska*

A survey course in poultry management can make valuable contributions to general education as well as lay the foundation for professional training. All of our students know something about poultry products, and with this background the teacher can develop what he believes to be a fundamental philosophy. Economists and sociologists, though differing in methods, are in general agreement that the well-being of mankind is promoted as we develop the program of—

(a) Efficient production.
(b) Efficient and fair distribution.
(c) Better living.

If then, the survey course can effectively develop these principles, it has a definite place in the field of general education which many educators believe is being greatly neglected at the present time.

The general content and objectives of such a survey course can, therefore, be expressed as follows:

1. To acquaint the student with the present distribution of the poultry industry and present day production trends.
2. To provide interesting and useful information about bird biology.
3. To enable the student to interpret consumer demands for poultry products and types of marketing services so that adaptations can be made to changing conditions.
4. To acquaint the student with present day developments in incubation and brooding equipment and practices.
5. To acquaint the student with principles of poultry housing and sanitation.
6. To acquaint the student with the principles of poultry nutrition.
7. To explain the system of poultry breed and variety classification and relationships between form and productive functions.
8. To enable the student to make a reasonable cost analysis of the jobs of producing broilers, market eggs, hatching eggs, baby chicks, turkeys, and other poultry products.

73. TRUE AND FALSE TESTS IN EXTENSION WORK

ARTHUR GANNON, *University of Georgia*

True-false tests have been found useful in extension work in Georgia. Once a month the Extension Poultryman prepares and mails to all County Extension Agents, who have expressed an interest, a mimeographed sheet containing 20 true-false statements. The Agent checks off the statements the way he thinks they should be answered and returns the sheet. The sheet is corrected at the office and sent back to the Agent with a two page discussion and with any number of extra copies requested.

The Agent may then use the test in his county in a number of ways, but most commonly in group meetings—with 4-H Clubs, women's groups and poultry meetings. The statements, after being answered by those present, form a good basis for discussion.

The tests have also been useful in holding one

day extension poultry schools and they have been especially helpful in conducting special courses for flock selecting and pullorum testing agents.

There are other variations in the use of the tests with extension projects. The idea has met with success in Georgia and has received many favorable comments from both County and Home Demonstration Agents in sections where there is interest in poultry. About 3,000 copies were distributed each month in Georgia, but the number varied from month to month.

74. SUBJECT MATTER OF ELEMENTARY AND ADVANCED TEACHING IN INCUBATION

ALEXIS L. ROMANOFF, *Cornell University*

The subject matter of college teaching in incubation has never been adequately outlined. Presumably the main difficulty lies in the complexity of the subject. Any comprehensive teaching of incubation inevitably blends with two fundamental sciences—physics on one side and embryology on the other. Neither science—physics or embryology—could be a part of the curriculum of the poultry department. Consequently, the subject matter of teaching of incubation has been left up to the personal ability and training of the teacher.

To formulate the subject matter of college elementary and advanced teaching it seems advisable, first, to analyze the extent of teaching done at various Agricultural Colleges throughout the country, and, second, to suggest the outlines of the subject matter most feasible under different conditions: (1) the outlines that will fit different training of teaching personnel, and (2) the outlines that will fit different time allotments in the curriculum of the department.

75. INCUBATION TEMPERATURE IN RELATION TO INHERENT VARIATION IN HATCHABILITY

T. C. BYERLY, *U. S. Department of Agriculture*

Six simultaneous incubations were made of eggs from the same hens at 97°F. and 99¾°F., respectively, and 6 at 99¾°F. and 102½°F., respectively, involving a total of about 10,000 eggs. These eggs were laid by crossbred hens which received excellent housing, feeding and management. The males used were rotated from pen to pen so that variation in hatchability among eggs from the various hens reflected the inherent hatchability of the eggs of those hens rather than variation in the inherent viability of the contained embryos. Inherent variation among the eggs of various hens in hatchability at normal temperature in cabinet-type incubators is shown to be positively correlated with the variation in hatchability of eggs from the same hens incubated either above or below the normal incubation temperature. Hatchability of the eggs of individual hens at abnormal temperature is reduced by about the same relative amount for eggs of low and high hatchability. Therefore, abnormal incubation temperature does not tend to eliminate chicks from hens whose eggs are inherently low in hatching power.

76. CHONDRODYSTROPHY IN THE CHICK EMBRYO PRODUCED BY A MINERAL DEFICIENCY IN THE DIET OF THE HEN

MALCOLM LYONS AND W. M. INSKO, JR., *Kentucky Agricultural Experiment Station*

The report of Wilgus and co-workers on the preventive action of manganese, aluminum, zinc and iron on the occurrence of slipped tendon (perosis) in young growing chicks together with our observations of a number of chicks hatched with slipped tendon, led us to study the effects on embryonic development and hatchability of feeding a slipped-tendon (perosis) producing ration to laying hens.

Eggs from hens that had been fed such a ration for two months gave a hatchability of less than ten percent. Those embryos that were sufficiently developed before death for observation, showed without exception, very short legs and wings and "parrot beak." The few chicks that hatched, although having short legs, did not have slipped tendon. Another group of hens fed the same ration plus 40 ppm. each of manganese and zinc, as the respective sulfates, and 100 ppm. of iron as ferrous ammonium sulfate produced eggs giving good hatchability and all normal chicks. Embryos that died showed normal development of appendages and mandibles.

The eggs from the hens fed the slipped-tendon producing ration contained much less manganese than those from the hens fed the same ration plus the mineral supplements indicated above. As a result of these analyses and of our studies on slipped tendon, we were inclined to attribute this condition to a manganese deficiency. This was proved to be correct by the injection of 0.03 mgs. of manganese directly into the albumen of such eggs just prior to incubation which resulted in normal development of the embryos and an increase of hatchability.

The tarsi, tibiae and humeri of the chicks and 20–21 day embryos from the injected eggs were

52, 44 and 40 percent longer respectively than the same bones of those from the eggs which were not injected with manganese. The injection of 0.03 mgs. of zinc into the albumen of the egg had no appreciable preventive effect on this disorder.

These findings may offer some insight into the mechanism which produces slipped tendon in the growing chick.

77. THE RELATION OF SELENIUM CONTENT OF GRAINS IN THE RATION TO THE SELENIUM CONTENT OF POULTRY CARCASS AND EGGS

A. L. MOXON AND W. E. POLEY,
South Dakota State College

Laying hens were fed balanced rations containing grains grown on seleniferous soils. The "all-mash" laying ration used contained 25 percent each of ground corn and barley and 15 percent of ground wheat in addition to the supplements. For those birds receiving selenium in their ration part of the normal grains were replaced with seleniferous grains, the amount of replacement depending upon the amount of selenium to be used. Four rations were used. Lot 1 received the control ration which included the normal grains. In Lot 2 part of the normal grains were replaced with seleniferous grains to include 2½ p.p.m. of selenium in the ration, and Lots 3 and 4 received 5 and 10 p.p.m. of selenium respectively.

After five weeks of feeding the birds were killed and selenium determinations made on the liver, kidneys, ovary, oviduct, ova, intestines and edible light and dark meats. In most cases the vital organs contained more selenium than the edible meat and in several cases the edible meat contained over 10 p.p.m. of selenium. There was considerable variation in the amount of selenium found but this was usually associated with the selenium content of the ration used.

With a few exceptions the selenium content of the eggs was also porportional to the amount contained in the ration.

78. THE INFLUENCE OF SOME DISTILLERY BY-PRODUCTS ON THE PRODUCTION OF CHICKEN FAT

G. DAVIS BUCKNER, W. M. INSKO, JR., J. HOLMES MARTIN, AND AMANDA HARMS,
Kentucky Agricultural Experiment Station

Distillers' dried grains or distillery slop in varying amounts were fed as parts of rations to chicks raised in battery brooders. The comparative quantities, qualities and proximate chemical analyses of fats deposited in several places in 10-weeks-old chicks raised under the different feeding conditions, were determined. Among other things, the results indicated that the displacement of ground yellow corn in a satisfactory all mash ration, even in part by distillery slop, caused smaller quantities of fats to be produced in the chicks. The quantitative differences produced by the substitution of distillers' dried grains for corn in the mashes were not so great. The comparative analyses of the fats produced by the different feeds will be discussed.

79. SUPPLEMENTARY FATS IN THE FATTENING RATION

W. A. MAW AND I. E. PUDDINGTON,
Macdonald College

The effect of the addition of varying levels of crude corn oil as a fat supplement to a mixed cereal ration (wheat, oats, and barley) on live weight gains during fattening and the total percent fat in the dressed carcass has been studied.

Mature-bodied Rhode Island Red cockerels were individually fed three times daily for a twenty-one-day period, recording body weights and feed consumption at seven-day intervals. Twenty-one individuals were used with each of the six rations. The initial weights of the birds were relatively uniform, and the gains for the twenty-one-day period show no significant differences between any two of the six rations used.

When the birds on each ration were subdivided into groups of seven birds each for the determination of any possible effect of the ration fed on gains according to seven-day feeding periods, the differences between rations, with the exception of one pair, show no significance. A significant difference was found between the rations: corn, wheat, oats, and barley, and the wheat, oats, and barley ration supplemented with two and one-half percent corn oil.

The analysis of the mean percent total fat in the drawn carcass of five birds from each ration showed no significant effect of the additional fat in the ration. However, the ration containing the corn cereal had a significantly greater amount of fat in the carcass than any of those other rations.

84. SULPHUR AND RICKETS

C. E. HOLMES, H. J. DEOBALD, AND C. A. HERRICK,
University of Wisconsin

Feeding flowers of sulphur in the rations of growing chicks will reduce losses from coccidiosis

to a marked extent. In our earlier trials no ill effects have been noted when the ration contained as much as two percent of flowers of sulphur for a period of ten months. In other trials, when the ration contained more than two percent of sulphur, the chicks had either access to direct sunlight or the sulphur feeding was discontinued after four weeks. No evidence of rickets was noted when the rations contained as much as ten percent sulphur and a half percent of good quality cod liver oil (175-225 U.S.P. units vitamin D per gram) for a period of four weeks.

If the sulphur feeding is continued for six weeks or longer and the chicks were dependent upon cod liver oil for their supply of vitamin D then rickets developed as manifested by reduced bone ash.

Special studies of the relationship between levels of sulphur and percentages of cod liver oil and the bone ash; ultra violet irradiation and sulphur feeding and the bone ash, blood calcium, and blood phosphorus are reported in this paper.

85. STUDIES OF THE EFFECT OF MANGANESE IN POULTRY RATIONS

P. J. Schaible, Selma L. Bandemer, and J. A. Davidson, *Michigan Agricultural Experiment Station*

Experiments were conducted as part of a project outlined to investigate the biological functions of certain minor mineral constituents in avian metabolism.

Manganese was added to ordinary practical poultry rations, low and high mineral perotic rations, and rachitic rations and its effect upon the growth, feather condition, leg bone and breast bone development of chicks studied.

Feedstuffs were analyzed for their manganese content and it was found that certain mineral supplements were frequently high in this element. The availability of manganese from various sources such as salts and ores was studied, and it was determined that all sources of manganese are not equally satisfactory when fed at definite levels.

86. THE INFLUENCE OF VARIOUS FORMS OF VITAMIN D ON HATCHABILITY

J. B. Smith and H. D. Branion, *Ontario Agricultural College*

A study of the influence of vitamin D as furnished by fortified cod liver oil, cod liver oil, irradiated cholesterol and pilchard oil, fed at four levels, each was made using an "all-milk" ration. About 35 International units per 100 grams of ration, of vitamin D in the form of cod liver oil and fortified cod liver oil gave good results, but 70 units appeared to be more profitable. The birds had access to sunshine on suitable days, although the amount available was low.

The vitamin D furnished by irradiated cholesterol was not as efficient as that furnished by the cod liver oil. Pilchard oil failed to promote satisfactory hatchability when fed at levels, equivalent to the cod liver oil in weight. Irradiated ergosterol was quite inefficient. The vitamin D requirement for egg production is not as high as that for hatchability. The occurrence of certain types of monsters and chondrodystrophy, oedema, and ectopia was in reverse proportion to the effectiveness of the vitamin supplement, both in kind and amount. Ninety-five units of irradiated cholesterol per 100 grams ration appeared to be as efficient as similar amounts of cod liver oil under indoor conditions.

From a consideration of all factors, fortified cod liver oil is slightly more efficient on a unit basis than the other supplements. A high level of this oil tended to depress egg production less than high levels of intake of the other supplements.

87. THE QUANTITATIVE VITAMIN G REQUIREMENT OF CHICKS

G. F. Heuser, H. S. Wilgus, Jr., and L. C. Norris, *Cornell University*

During the first eight weeks of life in the case of Single Comb White Leghorns there exists a fairly close relationship between the number of units of vitamin G per gram of gain, the number of units of vitamin G per gram of weight, the ratio of body-mass to gain, the units of vitamin G per 100 grams of feed and the instantaneous rate of gain.

The amount of feed consumed per bird per week increases in direct relation with age and is roughly inversely proportional to the instantaneous rate of gain.

Considering normal growth and food consumption, to supply the necessary amounts of vitamin G for White Leghorn chicks the ration should contain approximately the following amounts of vitamin G per 100 grams of feed for the second to eighth weeks, respectively: 350, 290, 240, 200, 160, 130, 100.

An increasing total number of units of vitamin G are required per week for each chick until weeks of age after which time there is a decrease until the eighth week. The units of vitamin G ranged from 325 to 415.

The close relation between units of vitamin G per gram of gain as well as the relation of unit

of vitamin G per gram of weight and the ratio of gains to mass suggests that vitamin G is closely related with growth and that the requirement for growth is much greater than the requirement for maintenance.

88. FLAVIN, A FACTOR IN CHICK NUTRITION

R. M. BETHKE AND P. R. RECORD,
Ohio Agricultural Experiment Station

Chicks fed a ration of yellow corn, wheat, wheat bran, Argentine casein, minerals, and cod liver oil grow poorly and a variable percentage of the birds develop a nutritional leg disorder, as previously described by Norris and associates and Bethke, Record, and Kennard. The feeding of 20 or more micrograms of lactoflavin, or synthetic ribo-flavin daily per chick resulted in a marked increase in growth and the prevention of the nutritional leg disorder.

The feeding of flavin also resulted in better feed utilization.

89. FURTHER STUDIES ON THE ANTI-GIZZARD-EROSION FACTOR REQUIRED BY CHICKS

H. R. BIRD, J. J. OLESON, C. A. ELVEHJEM, E. B. HART, AND J. G. HALPIN,
University of Wisconsin

Severe crater lesions have been found to occur in the gizzard linings of chicks fed a ration of heated dextrin, heated casein, salt mixture, raw peanuts yeast, and cod liver oil. Thickened, swollen gizzard linings have also been observed in chicks fed this ration and other experimental rations, particularly when finely ground. The addition of 5 percent of granite grit to the ration prevents swelling of the gizzard lining but seems to intensify the crater lesions. Hence in recent studies of these lesions the ration has been supplemented with grit.

As has been previously reported, oats is a good source of the anti-gizzard-erosion factor, and corn a poor source with wheat occupying an intermediate position. Wheat bran and middlings are somewhat superior to whole wheat.

Samples of whole oats, hulled oats, and rolled oats all taken from the same lot of grain were found to have the same potency with respect to the anti-gizzard-erosion factor. Fractionation of animal tissues rich in the factor indicated that it followed the proteins; however it could not be extracted from oats with dilute sodium hydroxide and samples of wheat of high and low protein content showed no difference in potency. Attempts to extract the factor from alfalfa and from wheat bran with fat solvents were unsuccessful.

90. THE VITAMIN D ACTIVITY FOR CHICKS OF A CHOLESTEROL DERIVATIVE

CARL H. SCHROEDER, H. ERNEST BECHTEL, AND W. A. HIGGINS, *Larro Research Farm*

"Chemo-Sterol D," a product prepared by chemical activation of Cholesterol and/or cholesterol-like materials, was compared with fish liver oil as a source of antirachitic substance for growing chicks in prophylactic feeding tests.

The two antirachitic agents were compared on the same U.S.P. vitamin D basis by incorporation, at 16 different levels, in an otherwise rachitogenic chick diet containing 56 percent of yellow corn meal.

When compared on the same rat unit basis, Chemo-Sterol D was a more efficient source of antirachitic substance than fish liver oil.

The relative efficacy of the two sources of vitamin D varied with the levels of antirachitic substances ingested in the ration. When used as the sole source of vitamin D, the data show that approximately one-fourth as many units in the form of Chemo-Sterol D, as in the form of fish liver oil, were required to protect growing chicks from rickets.